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ARTICLE 35 OF THE INTERNATIONAL CODE OF BOTANICAL NOMENCLATURE

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Lately in several of our Indian Journals, including the *Journal of the Indian Botanical Society*, a number of new species, varieties, etc., have been published, which according to the *International Code of Botanical Nomenclature* must be considered invalidly published. On more than one occasion I have privately called the attention of authors to Art. 35 of the Code; the prescriptions of Art. 35 had not been followed, and thereby publication of new species, etc., even when done in Latin, had become invalid. A few lines of explanation on Art. 35 and allied articles of the Code may be of interest to Indian botanists who may think of publishing some of their new findings in the field of Systematic Botany.

The wording of Art. 35 is quite plain, but may require some explanation for those who are not sufficiently familiar with the intricacies of the Code. Article 35 states: "Publication on or after 1st January 1958 of the name of a new taxon of recent plants of the rank of order or below is valid only when the nomenclatural type is indicated (*See* Arts. 7–10)". This article carries a recommendation: "Recommendation 35 A. When the nomenclatural type of a new taxon is a specimen, the place where it is permanently conserved should be indicated".

"Taxon" is a new term introduced in the 1956 edition of the Code and means such categories of plant classification as genera, species, varieties, etc. Article 35 applies to taxa like orders, families, genera, species, varieties or forms and to intermediate categories, but not to taxa above the rank of order.

Article 35 does not apply to fossil plants; it is only to recent ones, to modern plants that the prescriptions of Art. 35 apply. But then such prescriptions apply, it is to *all* modern plants, angiosperms, gymnosperms, mosses, liverworts, etc.

The meaning of Art. 35 will be made clear with an example. If I write, for instance, that "the type of this species was collected by

H. Santapau in Khandala on the Western Ghats of India on the 13th January 1958 and is kept in Blatter Herbarium, Bombay"; this does not fulfil the prescriptions of Art. 35. The correct way of putting it is the following: "The type of this species was collected by H. Santapau in Khandala on the Western Ghats of India on the 13th January 1958 and is kept in Blatter Herbarium, Bombay, *under reference number Santapau* 1254." The italicised words are essential according to Art. 35. Another way is to give the accession number of the herbarium, thus: "... and is kept in Blatter Herbarium, Bombay, *under accession number* 3596 *of* 1958", provided such accession number applies to only one specimen. The reference (accession or collector's number) must be such that it applies to one and only to one specimen; if there are several specimens mixed on the same sheet, the correct type must be singled out, as for instance, "*under reference number Santapau* 1254 *A*".

To give as reference the number of a *collection* does not fulfil Art. 35, if by a *collection* is meant a number of plants gathered in one day, or in one place, or in one field excursion. The reference number must pin-point the specimen in such a way that, should it later be necessary to consult the type, it may be possible to find it without any confusion or difficulty.

It may be noted that the herbarium, where the specimen is permanently preserved, may or may not be given; it is recommended that it be given, but if the herbarium is not indicated, publication does not automatically become invalid.

Article 10 explains what is meant by the word *Type* in the Code. "The nomenclatural type ...of a species or taxon below the rank of species is a single specimen or other element except in the following case: for small herbaceous plants and for most non-vascular plants, the type may consist of more than one individual, which ought to be conserved permanently and assembled on one herbarium sheet or preparation. If it is later proved that such a type herbarium sheet or preparation contains parts belonging to more than one taxon, the name must remain attached to that part (*lectotype*) which corresponds most nearly with the original description. (*Note.*—For plants of which it is impossible to preserve a type specimen or for a species without a type specimen, the type may be a description or figure.)"

The meaning of Art. 10 is quite plain. The type should be just *one* specimen, which may be a whole plant or a part of a larger plant. If there is more than one specimen on the same herbarium sheet, one must be selected as the type, this is the meaning of *lectotype*; if there are two branches of the same plant on one sheet, one branch must be the type, the other may be an *isotype* or a *paratype*; I shall say something on these two terms a little later. If there is a mixture of specimens on the type sheet, or in the bottle in which the type is preserved, the specimen most nearly representing the original description and illustrations, if any, must be selected as lectotype. In the case of microscopic or sub-microscopic algæ it may be difficult to separate the type from such

a mixture; clearly it is not in accordance with the Code to leave a whole mixture of Algæ together in a flask and say that one of them, to be sought for by the interested botanist, is the type; such a specimen should be, if possible, sorted out and mounted on a slide or kept in a different flask. In the case of the very large collection of sheets forming what is popularly referred to as *Wallich's Catalogue*, there are many sheets with more than one species; if the sheet is the type of any taxon, the individual specimen must be marked out clearly and be made into the lectotype. On the other hand, Roxburgh published a very large number of taxa in his book *Plants of the Coast of Coromandel*; Roxburgh had the actual specimens drawn or illustrated and described, after which the specimen itself was discarded; in such cases the illustration and description become the type, in accordance with the Note of Art. 10. In Algæ and Fungi, if for any reason it becomes impossible to preserve the type, then a plate giving essential differences may become the type.

Article 7 of the Code with its several notes explains the various terms used to signify the type specimen. "A nomenclatural type is that constituent element of a taxon to which the name of the taxon is permanently attached ..."; this is called the *Holotype* or simply *Type*. "A *holotype* ("type") is the one specimen or other element used by the author or designated by him as the nomenclatural type. For so long as a holotype is extant, it automatically fixes the application of the name concerned".

"An *isotype* is a duplicate of the holotype" (Art. 8, Rec. 8 A). Thus, suppose that two or more branches were collected from the same tree and mounted on one or more herbarium sheets: if one of the branches becomes the type or holotype, the others become isotypes; they are all duplicates of the same specimen, one of which is made into the type of the taxon. "A *paratype* is a specimen cited with the original description other than the holotype or isotype(s)." An example will make this clear. Suppose that you collect a branch of a tree in flower, and you make this branch the type or holotype; at some later stage you collect from the same or from other tree another branch in fruit; this second branch will form part of the original description and should be cited in the references as the *paratype*, that is to say, as a specimen on which the original description was based, but which is neither the type itself nor an isotype.

Linne and many of the older authors described large numbers of plants usually without defining the type specimen; this has caused much trouble and confusion. The members of the committee in charge of the preparation of the Code have tried to simplify matters by making it compulsory that every author who describes a new taxon shall define what his type may be. Article 35 was one of the important modifications introduced into the Code in the VIII International Botanical Congress at Paris; to avoid confusion and unnecessary changes in nomenclature, the Code does not wish to make this rule retroactive. As the rule stands at present, whatever be the type, a sheet in a herbarium, or a

bottled specimen, or a specimen made into a slide, or a figure or set of figures, it is necessary for the validity of the new name, *if published after 1st January* 1958, that the type be clearly indicated; this may be done by a number or in any other way, but the type must be so marked that it may be possible to distinguish it from any other specimen in the whole world. This is the meaning of Art. 35 of the *International Code of Botanical Nomenclature.*

Additional Notes

After this paper was sent to the press, some objections have been raised mainly by Algologists, against some of the points discussed in the paper. I shall attempt to answer such objections.

Point No. 1.—Some Algologists have remarked that in the case of some microscopic or sub-microscopic Algæ, it is impossible to preserve some of the essential characters in a slide; this is said to be the case, for instance, with the flagella or the eye-spot of the Volvolcales. In answer I may say that this is precisely one of the cases to which *Art.* 10, *Note* applies. The note states: "For plants of which it is impossible to preserve a type specimen or for a species without a type specimen, the type may be a description or figure". The spirit, if not the letter, of Art. 35 would, it appears, require that the author indicate that such a figure is the type of the new taxon.

However, even in Algæ, it is clear that Art. 35 is not fulfilled when the type is mentioned as one of the elements forming part of a collection in which more than one species may be preserved.

Point No. 2.—Failure to comply with the provisions of Art. 35 renders the publication of a new name invalid. For validation it is enough, in accordance with Art. 45, to give the type at a subsequent date. Article 45 states: "The date of a name or of an epithet is that of its valid publication. When the various conditions for valid publication are not simultaneously fulfilled, the date is that on which the last is fulfilled".

Point No. 3.—It is to be highly recommended that the place where the type specimen is kept should be clearly indicated; but this is only a recommendation. Failure to mention the place, does not invalidate the publication of a new taxon.

Point No. 4.—The *type* or *holotype* of a species should be a single specimen except for most non-vascular plants, in which the type may consist of more than one specimen, but the type "ought to be conserved permanently and assembled on one herbarium sheet or preparation" (Art. 10).

FRESH-WATER DIATOMS FROM SAGAR IN THE MYSORE STATE

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Synopsis

In this paper an illustrated systematic account is presented of Diatoms collected during a botanical excursion in January 1955 from Sagar area in the Mysore State. Some notes on their occurrence and distribution also are given.

Introduction

In the series of papers by the author on the Diatomflora of South-Western Zone of India, this one is based on several algal collections made from the vicinity of Sagar in the Mysore State. It lies at about 91 miles North-West of Birur on Birur-Talguppa line of the Southern Railway. Its geographical location is at 14° 10′ N. and 74° 70′ E. approximately, on one of the spurs of the Western Ghats. It has an annual rainfall of about 40–45 inches and an elevation over 1,900 feet above the mean-sea-level. The climate is moderate.

This place was visited on one of the botanical excursions during January 1955 leading to the Jog-falls. During a couple of days stay here, besides several phanerogamic plants (specimens are deposited at the Rajaram College Herbarium), quite many algal samples were gathered. Majority of these come from a rivulet which drains into the Saravati River system, some from a pond in neighbourhood of the railway station and other miscellaneous pools and puddles.

The algal samples from rivulet were taken by scraping the slimy and Podostemad encrustations on the rocky bed continuously moistened by running water and from pools and puddles there with abundant brown, loosely cluttered, living and dead vegetable matter. All these samples, on the spot, were preserved in 5% formalin. On return to the Rajaram College, where the author was working, all the samples were examined carefully besides many others till April 1956.

From the observations it was noted that the collections from the rivulet yielded a rich harvest of diatoms quite many of them being interesting in several respects. There is present the representative element of Java, Bali, Sumatra Islands (Hustedt, 1936, 1938–39), some of Indo-Malaya Archipelago (Hustedt, 1942) and Sino-Japanese type

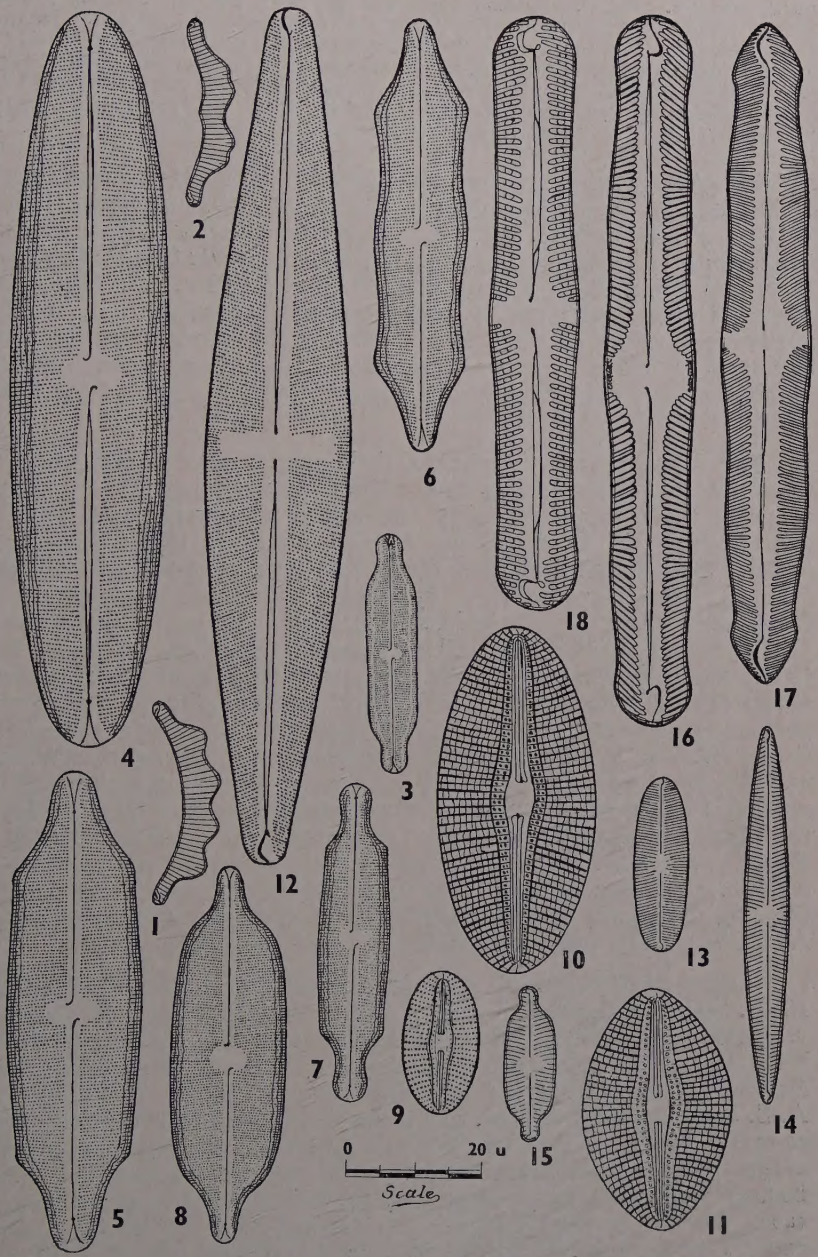
(Skvortzow, 1928, 1937). The Java, Bali, Sumatra and Indo-Malayan element can be spoken of essentially as tropical (Patrick, 1948), is the case here also, whereas the Sino-Japanese is subtropical to temperate. The tropical element here confines chiefly to hilly districts, as is understood from the present situation, also from the Jog-falls (the account is under preparation) and some similar localities on the Western Ghats. The geographical limits of these diatoms are extended and several new records for India are registered, besides some new for the Science.

So far the Diatomflora of this area is nowhere recorded, hence the author has an interest to present the said account. While preparing this paper, over 150 papers and monographs have been consulted though many of them do not appear in the bibliography. The new types recorded, of everyone except in a few cases, numerous specimens were observed and carefully considered. Further, full descriptions are given in cases of diatoms appearing as new for India or for the Science. Likewise the illustrations are given but some others are redrawn to suggest an improved aspect, correction or some new feature of interest over the existing Indian records. In certain cases more than one illustration is given to suggest the range of variation noted within the species since this aspect relates to life-history phases of such diatoms.

The number of diatoms discovered from the present area, there are about 62·5% species already recorded from different parts of India by previous workers. Of such species it is proposed here to give a list with a view to be brief. It is also that with the exception of a few individuals they do not represent any special feature of interest. However, while listing up these species, it is felt desirable to represent them into categories on the basis of their frequency, occurrence and distribution as could be made out from the collection, thus:—

The following diatoms were found to be widespread or common in the area and they ranged up to the Jog-falls. These were mostly seen in large numbers, quite many of them were gregarious, in one or the other body of water. The list runs thus: *Synedra ulna* (Nitz.) Ehr., *S.*—v. *amphirhynchus* (Ehr.) Grun., *Achnanthes minutissima* Kütz., *A. exigua* Grun., *Stauroneis phœnicenteron* Ehr., *S.*—f. *producta* Gandhi, *Navicula mutica* Kütz., *N. pupula* Kütz., *N.*—v. *capitata* Hust., *N. cryptocephaloides* Hust. (Fig. 36, 53), *N. cari* Ehr. v. *angusta* Grun. (Fig. 14), *N. dicephala* (Ehr.) W. Sm. v. *sphærophora* A. Cl. (Fig. 15), *Pinnularia interrupta* W. Sm. (Fig. 19), *P. viridis* (Nitz.) Ehr., *P.*—v. *intermedia* Cleve, *Amphora ovalis* Kütz. v. *pediculus* Kütz., *Cymbella amphicephala* Naeg. (Fig. 41), *Gomphonema parvulum* (Kütz.) Grun., *G. lanceolatum* Ehr., *G. subapicatum* Frit. & Rich, *G. clevei* Fricke (Fig. 48), *Nitzschia palea* (Kütz.) W. Sm., *Surirella linearis* W. Sm. (Fig. 29), *S. tenera* Greg., *S.* —v. *nervosa* A.S. and *S. subsalsa* W. Sm. All these diatoms ecologically either belong to lithophilous benthos or autophytic microphytic formation.

The diatoms, *Synedra ulna* (Nitz.) Ehr. v. *danica* (Kütz.) Grun., *Eunotia pectinalis* (Kütz.) Rabh. v. *gibbulosus* Venkat. (Fig. 33), *Caloneis silicula* (Ehr.) Cl., *C.*—f. *recta* Jur. (= *C.*—v. *interrupta* Venkat.),



TEXT-FIGS. 1–18. Fig. 1. *Eunotia camelus* (Grun.) Å. Berg. v. *karveerensis* Gandhi. Fig. 2. *Eunotia camelus* v. *ventricosa* Gandhi. Fig. 3. *Neidium affine* (Ehr.) Cl. v. *longiceps* (Greg.) Cl. Fig. 4. *Neidium iridis* (Ehr.) Cl. Fig. 5. *Neidium productum* (W. Sm.) Cl. v. *bombayensis* Gonzalves and Gandhi. Fig. 6. *Neidium*

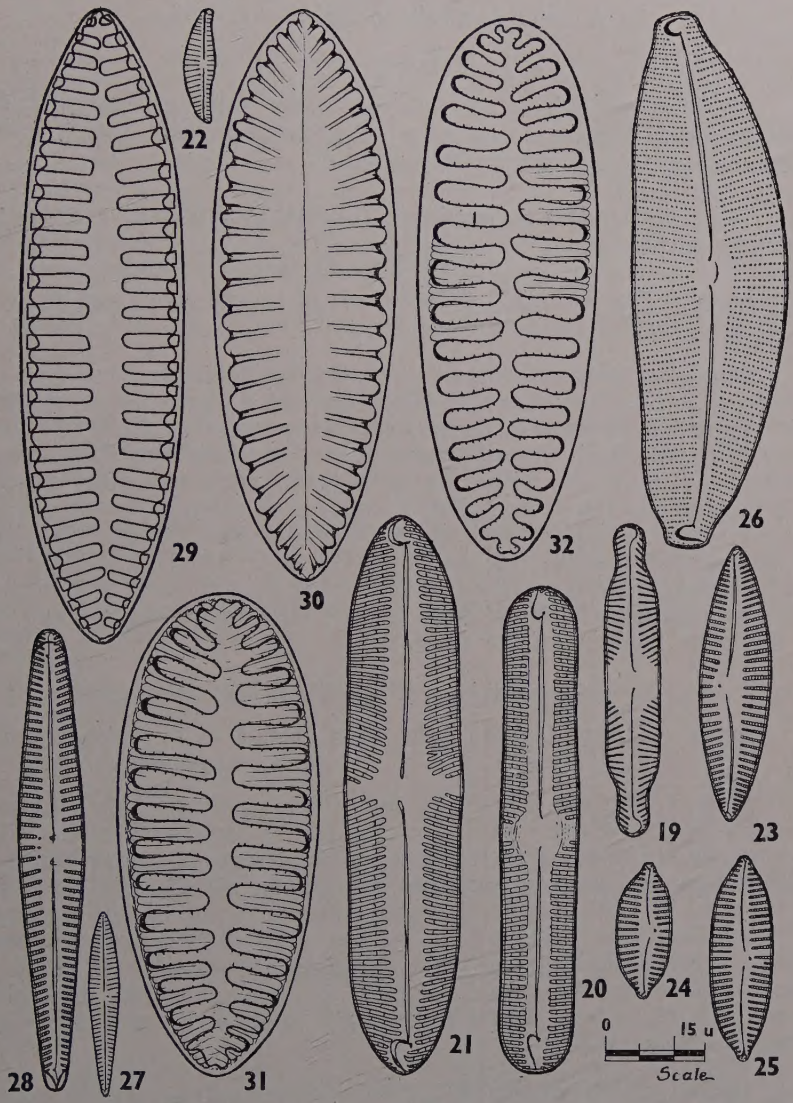
gracile Hustedt. Fig. 7. *Neidium capitellata* sp. nov. Fig. 8. *Neidium grandis* sp. nov. Fig. 9. *Diploneis elliptica* (Kütz.) Cl. Figs. 10–11. *Diploneis elliptica* v. *ladogensis* Cl. Fig. 12. *Stauroneis phœnicenteron* Ehr. v. *crumenifera* (Mayer) Cl. Fig. 13. *Navicula cocconeiformis* Greg. v. *oblonga* v. nov. Fig. 14. *Navicula cari* Ehr. v. *angusta* Grun. Fig. 15. *Navicula dicephala* (Ehr.) W. Sm. v. *sphærophora* A. Cl. Fig. 16. *Pinnularia graciloides* Hustedt. Fig. 17. *Pinnularia sagittata* sp. nov. Fig. 18. *Pinnularia mysorense* sp. nov.

Neidium affine (Ehr.) Cl. v. *longiceps* (Greg.) Cl. (Fig. 3), *Navicula cuspidata* Kütz., *N.*—v. *ambigua* (Ehr.) Cl., *Pinnularia acrosphæria* (Bréb.) W. Sm., *P. microstauron* (Ehr.) Cl. v. *ambigua* Meister, *Gomphonema intricatum* Kütz. v. *vibrio* (Ehr.) Cl. (Fig. 46), *G. spicula* Gandhi (Fig. 50), *Epithemia zebra* (Ehr.) Kütz., *Rhopalodia gibba* (Ehr.) O. Müll. and *Nitzschia lorenziana* Grun. v. *subtilis* Grun., appeared in a smaller number and some as stray forms. This group element here is characteristic of bodies of water (fresh-water) other than streams and the rivulet, and the individual species occurred with benthos of the loose soil.

The following are the characteristic species of standing water in the rivulet and streams, since they seldom occurred elsewhere. Leaving a few of these, they were fairly represented in several pools, puddles and ditches. Of these species, *Eunotia pectinalis* (Kütz.) Rabh. v. *neglecta* Gandhi and *E. camelus* (Grun.) Å. Berg v. *karveerensis* Gandhi (Fig. 1), were planktonic or subplanktonic elements—occurring in free-floating chain or ribbon-like formations. *Caloneis silicula* (Ehr.) Cl., *Cymbella aspera* (Ehr.) Cl., *C. aspera*? (Fig. 45), *C. bengalensis* Grun. and *Surirella subsalsa* W. Sm., represent lithophilous benthos group since all these species were found to form slimy deposition on partially submerged rocks or loose stones. The diatoms, *Surirella linearis* W. Sm., *S. tenera* Greg., *S.* —v. *nervosa* A.S., *S. subsalsa* W. Sm. and *Nitzschia tryblionella* Hantz. v. *victoriæ* Grun., appeared well in number with brownish masses of dead vegetable matter lying on loose soil (benthos of the loose soil); whereas, *Eunotia pectinalis* (Kütz.) Rabh. v. *neglecta*? (Fig. 34), *E. camelus* v. *ventricosa* Gandhi (Fig. 2), *Neidium productum* (W. Sm.) Cl. v. *bombayensis* Gonzal. and Gandhi (Fig. 5), *Pinnularia acrosphæria* (Bréb.) W. Sm. and *P. angustefasciata* A. Cl. (Fig. 21), were represented as stray specimens.

Again, the diatoms: *Eunotia pectinalis* v. *gibbulosus* Venkat., *E.*—v. *neglecta* Gandhi, *Navicula cari* v. *angusta* Grun., *N. dicephala* v. *sphærophora* A. Cl., *Pinnularia interrupta* W. Sm., *P. viridis* (Nitz.) Ehr., *P.* —v. *intermedia* Cleve, *Nitschia tryblionella* v. *victoriæ* Grun., *Surirella linearis* W. Sm. (Fig. 29), *S. tenera* Greg., *S.* —v. *nervosa* A. S. and *S. subsalsa* W. Sm. and a few others, are known mostly from several hilly districts of the Western Ghats as this zone has been a subject of the author's exploration. From the observations, two points become more or less apparent, *viz.* (1) this element is probably characteristic of the hilly regions, and (2) the range of its distribution extends from Bombay-Salsette Islands down upto the Jog-falls.

Regarding all other diatoms notes are given under the individual species as it is being felt convenient.



TEXT-FIGS. 19–32. Fig. 19. *Pinnularia interrupta* W. Smith. Fig. 20. *Pinnularia cardinaliculus* (Cl.) Lund. Fig. 21. *Pinnularia angustefasciata* A. Cl. Fig. 22. *Cymbella javanica* Hustedt. Fig. 23. *Cymbella japonica* Reichelt. Figs. 24–25. *Cymbella sagarensis* sp. nov. Fig. 26. *Cymbella rivularis* sp. nov. Fig. 27. *Gomphonema acuminatum* Ehr. v. *directum* A. Cl. Fig. 28. *Gomphonema tropicale* Brun. Fig. 29. *Surirella linearis* W. Sm. Fig. 30. *Surirella celebesiana* Hustedt. Figs. 31–32. *Surirella horrida* Hustedt. *f. minor f.* nov.

A Systematic Enumeration of the Diatoms

1. *Eunotia pectinalis* v. *gibbulosus* Venkat.

(Text-Fig. 33)

The illustration depicts a deformed valve noted in the collection. The deformity appears at one end which is much broader than the other and some striæ are incompletely formed.

2. *Eunotia pectinalis* v. *neglecta* Gandhi

(Text-Fig. 34)

Gandhi, *Diat. Radhanagari*, 1957, 47, pl. 13, f. 3–5: Length 55–60 μ, breadth 6·7–7 μ and striæ 14–15 in 10 μ.

Some slim looking forms of which the illustration is given occurred in the collection from this area which resembled the said type in shape and somewhat in range of dimensions. However, they tended to show two differences from the others and those recorded from Radhanagari material, *viz.*, (1) the striæ are closely and more uniformly set and (2) the raphe at the polar nodule seemed to be sharply bent or reflexed as seen in *E. pseudopectinalis* Hust. (Hustedt, *Diat. Sarek.*, 1924, 547, t. 18, f. 1; Cleve-Euler, *Diat. Schwed.* Finn.—II, 1953, 92, f. 418). But unfortunately due to paucity of the material studies could not be made with any certainty. Hence, such forms I treat under the said type till I get more material of the same.

3. *Caloneis silicula* (Ehr.) Cl. f. *recta* Jur.

Jurilj, A., *Diat. Ochrida Lake*, 1954, 144, f. 49 *c*; Venkataraman, G., *Diat. S. I.*, 1956, 4, f. 9 (= *C. silicula* v. *interrupta* Venkat.).

With *C. silicula* (Ehr.) Cl., some stray specimens also occurred having the central area widened to sides as illustrated by Venkataraman. From the study of these specimens and subsequent comparison with illustrations and descriptions given by Jurilj for *C. silicula* f. *recta* Jur. (described in 1952) and by Venkataraman for *C. silicula* v. *interrupta* Venkat. (described in 1956), I make out no difference whatsoever between these. Hence, according to rule of priority, I consider *C. silicula* v. *interrupta* Venkat. to be *C. silicula* f. *recta* Jur. The dimensions recorded of the local forms are: length 20–30 μ, breadth 5–6 μ and striæ 18–20 in 10 μ.

4. *Neidium affine* (Ehr.) Cl. v. *longiceps* (Greg.) Cl.

(Text-Fig. 3)

Gandhi, *Soil Diat. Kolhapur*, 1956, 403, f. 1: Length 33–40 μ, breadth 6·6–7 μ and striæ 26–28 in 10 μ.

The specimens from this region show larger dimensions and somewhat capitate ends than those recorded from Kolhapur region.

5. *Neidium iridis* (Ehr.) Cl.

(Text-Fig. 4)

Hustedt, *Bacil.*, 1930, 245, f. 379; Cleve-Euler, A., *Diat. Schwed. Finn.*—IV, 1955, 119, f. 1174 *a–b* (= *N. iridis* v. *genuina* May. f. *major* A. Cl.); Donkin, *Brit. Diat.*, 1871–73, 30, pl. 5, f. 6 (= *Navicula iridis* Ehr.); Van Heurck, *Treat. Diat.*, 1896, 220, pl. 5, f. 212 (= *Nav. iridis* Ehr.): Valves 86–132 μ long and 18–24·2 μ broad, linear-elliptical with more or less broadly rounded ends. Raphe thick with central pores bent in opposite directions and terminal fissures bifurcated. Axial area narrowly linear, somewhat widened in between; central area fairly large, somewhat obliquely elliptical or subrounded. Striæ 16–18 in 10 μ, clearly punctate, slightly obliquely disposed in the middle and convergent at the ends, crossed by a few longitudinal furrows near the margins.

Hustedt indicates in his illustration rather more narrowed apices due to which the outline appears lanceolate-elliptical. The specimens observed from this area are distinctly like those illustrated by Donkin, Van Heurck and Cleve-Euler.

This species was collected in a good number from among the Podostemad encrustations and some pools and puddles in the rivulet. It occurred as lithophilous benthos as well as the benthos of the loose soil. It is a very conspicuous diatom being large and robust. Moderately distributed in the region.

6. *Neidium productum* (W. Sm.) Cl. v. *bombayensis* Gonzal. and Gandhi

(Text-Fig. 5)

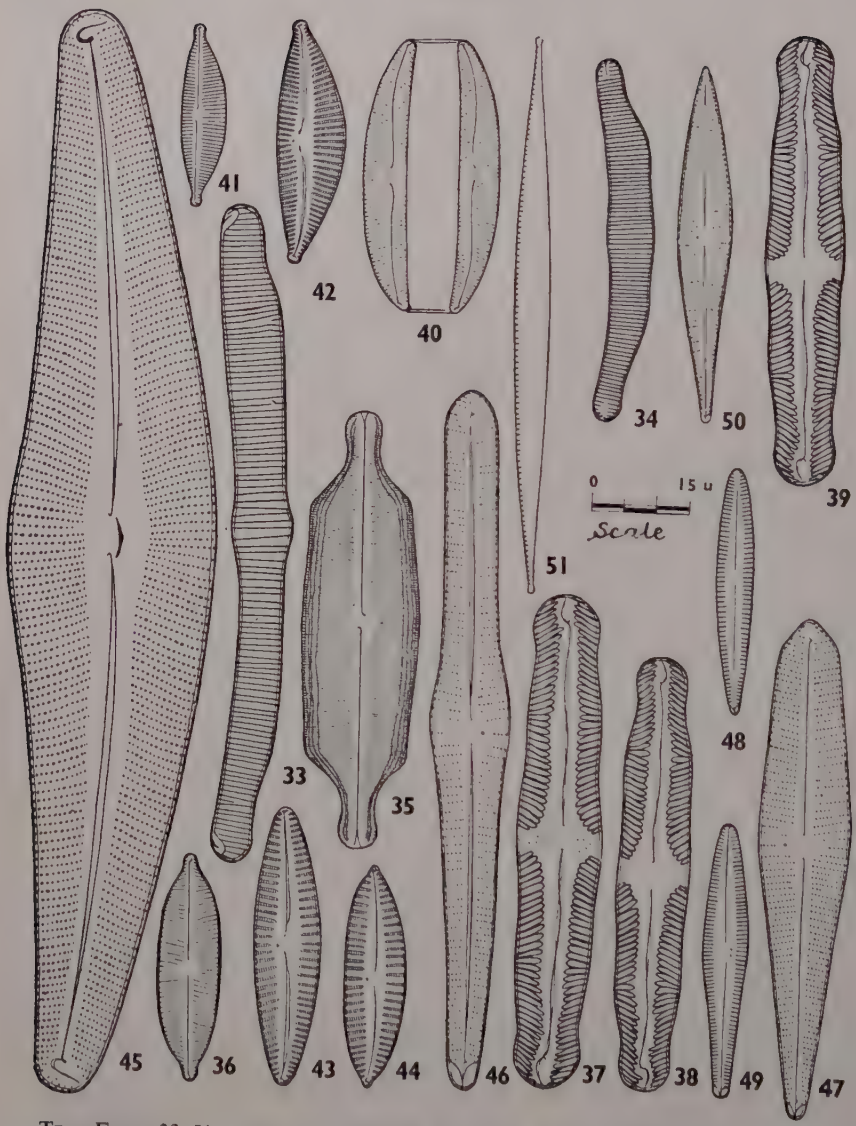
Gonzalves and Gandhi, *Diat. Bom. Sals.*—II, 1953, 250, f. 81: Length 68–83·6 μ, breadth 18–22 μ and striæ 20–22 in 10 μ.

The specimens collected from this region show a smaller range of dimensions and somewhat less produced apices than those recorded from Bombay and Salsette Islands.

7. *Neidium gracile* Hustedt

(Text-Fig. 6)

Hustedt, *Diat. Sunda-Exped.*, 1938, 406, t. 16, f. 8–9: Valves 44–60·5 μ long and 10–13·2 μ broad, linear, sides clearly triundulate with somewhat abruptly narrowed, gracefully produced, cuneate rounded ends. Raphe thin and straight with central pores bent in opposite directions and terminal fissures bifurcated. Axial area narrow, linear; central area quite large, rounded or feebly obliquely elliptical. Striæ 20–22 in 10 μ, clearly punctate, slightly obliquely set in the middle and convergent at the ends, crossed by a few longitudinal furrows near the margins.



TEXT-FIGS. 33–51. Fig. 33. *Eunotia pectinalis* (Kütz.) Rabh. v. *gibbulosus* Venkat. Fig. 34. *Eunotia pectinalis* v. *negiecta* Gandhi. Fig. 35. *Neidium capitellata* sp. nov. Fig. 36. *Navicula cryptocephaloides* Hustedt. Figs. 37–39. *Pinnularia graciloides* Hustedt. Fig. 40. *Amphora ovalis* Kütz. v. *affinis* Kütz. Fig. 41. *Cymbella amphicephala* Naeg. Fig. 42. *Cymbella affinis* Kütz. Fig. 43. *Cymbella japonica* Reichelt. Fig. 44. *Cymbella sagarensis* sp. nov. *f. gracilis f.* nov. Fig. 45. *Cymbella aspera* (Ehr.) Cl. Fig. 46. *Gomphonema intricatum* Kütz. v. *vibrio* (Ehr.) Cl. Fig. 47. *Gomphonema lanceolatum* Ehr. f. *turris* (Ehr.) Hustedt. Fig. 48. *Gomphonema clevei* Frieke. Fig. 49. *Gomphonema clevei* v. *bipunctata* v. nov. Fig. 50. *Gomphonema spicula* Gandhi. Fig. 51. *Nitzschia pseudogracilis* sp. nov.

This species was seen in a small number in brownish stuff formed with Podostemad encrustations in the rivulet. Elsewhere in the locality not seen. It is interesting that this species appears like *N. hitchcockii* (Ehr.) Cl. [Cleve-Euler, *Diat. Schwed. Finn.*—IV, 1955, 116, f. 1169 *a*; Donkin, *Brit. Diat.*, 1871–73, 29, pl. 5, f. 4 (= *Navicula hitchcockii* Ehr.), and it is known only from Java, Bali and Sumatra islands, therefore, its occurrence in India extends the geographical limits.

8. *Neidium capitellata* sp. nov.

(Text-Figs. 7, 35)

Valvæ 46–86 μ longæ atque 10–23 μ latæ, lineares-ellipticæ, ad margines paululum triundulatæ atque apicibus abrupte constrictis, producto-rotundato-capitatis. Raphe tenuis et recta, ornata poris centralibus inclinata in directione contraria ac fissuris terminalibus bifurcatis. Area axialis angusta-linearis ac paulum dilatata in medio; area centralis ampla, rotundata. Striæ 26–28 in 10 μ, subtiliter punctatæ sed distincte, radiales in medio ac paululum convergentes ad apice, sulcis longitudinalibus paucibus interruptæ ad margines.

Valves 46–86 μ long and 10–23 μ broad, linear-elliptical with feebly triundulate sides and abruptly narrowed, produced, capitate rounded ends. Raphe thin and straight with central pores bent in opposite directions and terminal fissures bifurcated. Axial area narrow, linear and somewhat widened in between; central area fairly large and rounded. Striæ 26–28 in 10 μ, finely but distinctly punctate, radial in the middle and very slightly convergent at the ends, crossed by a few longitudinal furrows near the margins.

This species shows some resemblance with *N. productum* v. *bombayensis* Gonzal. and Gandhi, described above in its outline, central and axial areas. However, it differs from it in having capitate ends. Moreover, the striæ are much denser and more finely punctate. Further, the middle striæ are not at all obliquely disposed as could be discerned by actual comparison. It is, therefore, regarded as a new species.

This species was observed in Podostemad encrustations in running water of the rivulet forming slimy films. It also occurred in some pools and puddles cluttered with brownish masses of matter. Stray specimens also were seen in a pond. Fairly distributed in the locality. This form was also collected from Lonavla Hill-station from similar habitats as well as from some clusters of wet liverworts, some years ago. Slide no. 750.

9. *Neidium grandis* sp. nov.

(Text-Fig. 8)

Valvæ 45–55 μ longæ atque 14–14·5 μ latæ, lineares-ellipticæ, marginibus paululum convexo, apicibus abrupte constrictis in leviter niflexo atque distincte producto-rotundatis. Raphe tenuis et recta, poris centralibus distincte inclinata in directione contraria ac fissuris terminalibus bifurcatis. Area axialis angusta, linearis; area centralis

ampla, elliptica vel rotundata. Striæ 26–28 in 10 μ, subtiliter punctatæ, radiales, sulcis longitudinalibus paucibus interruptæ ad margines.

Valves 45–55 μ long and 14–14·5 μ broad, linear-elliptical, margins feebly convex, towards the ends abruptly narrowed in a smooth arch into narrowed rounded ends distinctly produced. Raphe thin and straight with central pores distinctly bent in opposite directions and terminal fissures bifurcated. Axial area narrow, linear; central area fairly wide, elliptical to rounded. Striæ 26–28 in 10 μ, finely punctate and radial, crossed by some longitudinal furrows near the margins.

This diatom is curious in that it does not exactly resemble, (1) *Neidium dubium* (Ehr.) Cl. (Hustedt, *Bacil.*, 1930, 246, f. 384; Jurilj, *Diat. Ochrida Lake*, 1954, 143, f. 47 *c–d*; Cleve-Euler, *Diat. Schwed. Finn.*—IV, 1955, 116, f. 1170 *a-d* (= *N. dubium* v. *genuinum* Mayer); Van Heurck, *Treat. Diat.*, 1896, 221, pl. 5, f. 215 (= *Navicula dubia* Ehr.); Donkin, *Brit. Diat.*, 1871–73, 30, pl. 5, f. 5 (= *Nav. dubia* Ehr.); (2) *Neidium productum* (W. Sm.) Cl. (Hustedt, *op. cit.*, 245, f. 383; Cleve-Euler, *op. cit.*, 118, f. 1171 *a–c*; Tiffany and Britton, *Alg. Illinois*, 1952, 263, pl. 71, f. 820 [= *N. productum* (W. Sm.) Pfit.]; or (3) *Neidium bruunii* Foged (Foged, N., *Diat. Rennell Isl.*, 1957, 61, pl. 5, f. 7), although it has a shape similar to all these three species. The apices in the forms collected here are more produced, narrower and prominent than in *N. dubium*. These forms are comparatively larger with larger central area and greater number of striæ, thus they differ from *N. dubium*. With *N. productum*, they differ in having more abruptly narrowed and less produced ends besides having dense, finely punctate striæ and the striæ not at all obliquely set in the middle part. In this way the forms in question also differ from *N. productum*. The *Neidium bruunii* strongly resembles in shape and narrowly rostrate-rounded apices, but differs in dimensions, central area and widely set striæ (dimensions recorded by Foged for *N. bruunii* are: length 33 μ, breadth 13 μ and striæ 15–16 in 10 μ), hence the present forms cannot be compared with this species also.

The material collected from Bombay and Salsette Islands (Gonzalves and Gandhi, 1953), had also yielded these forms along with *N. dubium*, and on comparison they were found to be markedly different in apices, *i.e.*, apices in *N. dubium* were broad and shortly rostrate, besides the striæ being less denser than those found in other forms which were like the present species. Such forms were then not entertained for want of clear understanding, but now they are considered to be a new species in light of the above-mentioned facts. However, it can be said that *N. dibium*, *N. productum*, *N. bruunii* and *N. grandis*, *i.e.*, the present species, have more or less a similar outline.

This species was collected in a good number from encrustations formed by Podostemads and some Myxophyta. It was also seen in samples from pools, puddles and ditches in the rivulet, mixed up in brownish masses of dead vegetable matter. Common in the locality and noted up to the Jog-falls. Slide no. 751.

10. *Diploneis elliptica* (Kütz.) Cl.

(Text-Fig. 9)

Hustedt, *Bacil.*, 1930, 250, f. 395; Cleve-Euler, *Diat. Schwed. Finn.*—III, 1953, 78, f. 646 *b* (= *D. elliptica* v. *genuina* Meister); Van Heurck, *Treat. Diat.*, 1896, 201, pl. 4, f. 156 (= *Navicula elliptica* Kütz.); Donkin, 1871–73, 7, pl. 1, f. 6 *a–b* (= *Nav. elliptica*): Valves 20–40 μ long and 11–15 μ broad, elliptical to slightly rhombic-elliptical. Raphe between the ribs, ribs widened in the central nodule. Axial area very narrow, central area slightly inflated. Furrows narrow, widened in the middle, lanceolate. Costæ 10–13 in 10 μ, radial at the ends, alternating with a single row of coarse punctæ (alveoli).

This species was well represented in the locality particularly in encrustations of Podostemads. It was also found in various other pools and puddles there in the rivulet. Some miscellaneous samples of algæ also contained it but sparingly. Well distributed up to the Jog-falls.

11. *Diploneis elliptica* v. *ladogensis* Cl.

(Text-Figs. 10–11)

Hustedt, *Bacil.*, 1930, 250, f. 396; Skvortzow, *Diat. Kizaki Lake*, 1937, 32, pl. 2, f. 3, 6; Cleve-Euler, *Diat. Schwed. Finn.*—III, 1953, 78, f. 646 A, *b–c*: Valves 23–51·4 μ long and 12–24 ·2 μ broad, elliptical to rhombic-elliptical. Raphe between the ribs, ribs widened in the central nodule. Axial area very narrow, central area slightly dilated, quadrate to elliptical. Furrows separating 1–2 alveoli from the rest, narrowly lanceolate and dilated in the middle. Costæ about 9 in 10 μ (8–9·5 in 10 μ), radial at the ends, alternating with a single row of very coarse punctæ or alveoli, alveoli 8–9 in 10 μ, alveoli somewhat irregularly arranged due to which longitudinal ribs become irregular.

This diatom was observed in several collections from the rivulet, occurring both in Podostemad encrustations as well as in pools and puddles. It was found either in association of the above species or independently forming local colonies. Fairly well distributed in the area upto the Jog-falls.

12. *Stauroneis phœnicenteron* Ehr. v. *crumenifera* (Mayer) Cl.

(Text-Fig. 12)

Cleve-Euler, *Diat. Schwed. Finn.*—III, 1953, 210, f. 944 *h–i*: Valves 122–156 μ long and 19–22 rarely 24 μ broad, narrow rhombic-lanceolate with scarcely produced somewhat blunt ends. Raphe thick with conspicuous central pores and slightly curved terminal fissures. Axial area narrow, linear; central area a linear stauros with short striæ. Striæ 18–20 in 10 μ, clearly punctate, punctæ fine, striæ strongly radial towards the apices.

This diatom was represented in a good number primarily in some pools and puddles in the rivulet, mixed up with brownish slimy matter and secondarily in encrustations on the wet rocks. Some stray specimens were also seen in a pond and a slowly flowing watercourse.

13. *Navicula cocconeiformis* Greg. v. *oblonga* v. nov.

(Text-Fig. 13)

Valvæ 20–26 μ longæ atque 8–8·5 μ latæ, oblongo-ellipticæ. Raphe tenuis et recta, poris centralibus distincte atque fissuris terminalibus curvatis. Area axialis angustissima; area centralis minuta, elliptica. Striæ 18–24 in 10 μ, tenues, ubique radiales, striæ longæ ac brevis alternare in medio.

Valves 20–26 μ long and 8–8·5 μ broad, oblong-elliptical. Raphe thin and straight with central pores distinct and terminal fissures curved. Axial area very narrow; central area small and elliptical. Striæ 18–24 in 10 μ, fine, radial throughout, long and short striæ alternate in the middle.

This diatom differs from *N. cocconeiformis* Greg. (Hustedt, *Bacil.*, 1930, 290, f. 493), in having oblong-elliptical outline. It is referred to the said type since its middle striæ are similarly arranged though they are slightly fewer in number. Another similar looking form is *N. limatoides* Hust. (Hustedt, *Diatomfl. norddeut. Seen.*, 1950, 350, t. 38, f. 34–35), but in this form the striæ are distantly set and the middle striæ, though some are short, do not regularly alternate as seen in the present species Since, the present diatom compares well with *N. cocconeiformis* in arrangement of the middle striæ, it is hence considered to be its new variety.

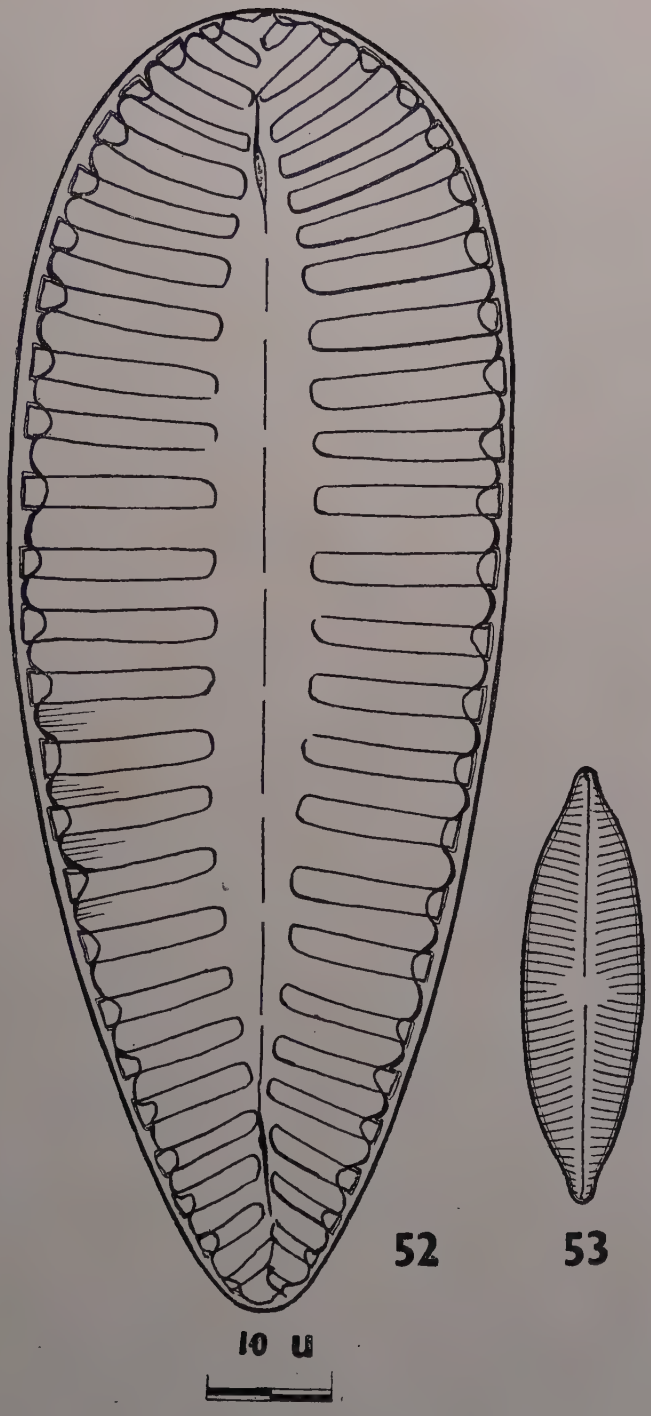
This diatom was collected from some pools and puddles in the rivulet occurring there with brownish masses of slimy matter. In Podostemad encrustations, it was seen as a stray form. It occurred only in about 15% of samples. Slide no. 748.

14. *Navicula cryptocephaloides* Hust.

(Text-Figs. 36, 53)

Hustedt, *Diat. Sunda-Exped.*, 1938, 261, t. 18, f. 1–2; Gandhi, *Diat. Hirebhasgar-dam*, 1957, 257, f. 12 (= *N. rostellata* Kütz.): Valves 30–40 μ long and 8–10 μ broad, linear-lanceolate with somewhat abruptly constricted, produced rounded ends. Raphe thin and straight with terminal fissures curved. Axial area narrow, linear; central area fairly wide, rounded or slightly quadrate. Striæ 12–14 in 10 μ, lineate, slightly radial in the middle and convergent at the ends.

With the availability of Hustedt's monograph on Java, Bali and Sumatra Diatoms and occurrence of diatoms looking similar to those described as *N. rostellata* Kütz., with hesitation, from the Hirebhasgar-dam area, it became imperative to re-examine them. As a consequence of the re-examination, it was realized that present specimens as well as *N. rostellata* from the Hirebhasgar-dam area could be referable to *N. cryptocephaloides* Hust. This is being done here. The number of striæ 10–14 in 10 μ, recorded for Hirebhasgar specimens, should be noted as 12–14 in 10 μ.



TEXT-FIGS. 52–53. Fig. 52. *Surirella capronioides* sp. nov. Fig. 53. *Navicula cryptocephaloides* Hust.

15. *Pinnularia graciloides* Hustedt

(Text-Figs. 16, 37–39)

Hustedt, *Diat. Sunda-Exped.*, 1938, 293, t. 22, f. 9–10; *Diat. Wallacea-Exped.*, 1942, 82, f. 155–58; *Diat. Tobasees Sumatra*, 1936, 159, t. 2, f. 13 (= *P. gracilis* Hust.): Valves 66–120 μ long and 11–13 μ broad, linear, sides triundulate sometimes more bulged in the middle with capitate rounded ends. Raphe thin or thick, somewhat undulate to appear complex with unilaterally bent central pores and bayonet-shaped terminal fissures. Axial area fairly wide, linear about $\frac{1}{5}$–$\frac{1}{4}$ the width of the valve; central area large, rhomboid, reaching the sides, in larger specimens some irregular markings or punctæ are seen on either sides of the central nodule or towards the margins. Striæ 9–11 in 10 μ, somewhat thick and closely set, strongly radial in the middle and convergent at the ends.

Hustedt has described this species from Sumatra region as *P. gracilis* which does not show scattered punctæ in the central area, while other specimens collected by him from Java, Bali and Sumatra islands and Indo-Malaya Archipelago region, are described and illustrated to have some scattered punctæ in the central area, at least in some cases. In addition to this, the original name *P. gracilis* is changed to *P. graciloides* for the reason of two such names already existing in the literature. Also with more detailed observations, particularly of Indo-Malayan material, the larger length is registered which now becomes from a maximum of 85 μ to 125 μ. The raphe in the original illustration was shown to be thin but undulate (hence complex), is now indicated to be complex in material from Sunda- and Wallacea-expeditions. While considering *P. gibba* Ehr. f. *subundulata* Mayer (Hustedt, *Bacil.*, 1930, 327, f. 601), the outline is remarkably similar as also the range of dimensions and the arrangement of striæ. The only differences which could be pointed out are: (1) the raphe is very straight in *P. gibba* f. *subundulata* with approximate central pores and curved terminal fissures, (2) the striæ though practically the same in number are not set so closely in *P. gibba* f. *subundulata*. Cleve-Euler refers *P. gibba* f. *subundulata* to *P. stauroptera* (Rabh.) Cl. v. *longa* A. Cl. (Cleve-Euler, *Diat. Schwed. Finn.*—IV, 1955, 67, f. 1091 *g–i*), but the illustrations given do not compare well with that of Hustedt's. With these considerations and the material at my disposal, I consider my specimens fitting well with *P. graciloides*, and so they are treated. The point, of punctæ being absent on either side of the central nodule in some of the present forms is treated as an exception, since such specimens have been recorded by Hustedt also.

This species was collected in a good number from several bodies of fresh-water found in the region. It was specially more frequent in pools and puddles in the rivulet, where it occurred in brownish masses of matter (as a benthos of loose soil). It is a common diatom in the locality.

16. *Pinnularia interrupta* W. Sm.

(Text-Fig. 19)

The species collected from this region show a wider range of dimensions: length 34–52·8 μ, breadth 6·6–8·2 μ, than those recorded from the Hirebhasgar-dam area. Moreover, the apices are only slightly capitate.

17. *Pinnularia sagittata* sp. nov.

(Text-Fig. 17)

Valvæ 90–95·8 μ longæ atque 12·5–13 μ latæ, sublineares, marginibus aliquantum sed distincte triundulatæ, apicibus distincte constrictis, acuto-cuneatæ, capitatæ. Raphe tenuis, aliquantum undulata vel subcomplexa, ornata poris centralibus proximæ positæ cum paulum unilateraliter inclinata atque fissuris terminalibus paulum curvatis. Area axialis ampla, circiter $\frac{1}{4}$ latitudinis valva, linearis vel sublinearis; area centralis magna, rhomboidea, parva versus ad margines perveniens. Striæ 10–12 in 10 μ, aliquantum crassa, radiales in medio ac in utroque apice convergentes.

Valves 90–95·8 μ long and 12·5–13 μ broad, sublinear with weak but distinct triundulate sides and distinctly narrowed, acutely-wedge-shaped capitate ends. Raphe thin but somewhat undulate or subcomplex with closely set central pores unilaterally bent and weakly curved terminal fissures. Axial area fairly wide, about $\frac{1}{4}$ the width of the valve, linear or sublinear; central area large, rhomboid, narrowly reaching the sides. Striæ 10–12 in 10 μ, slightly thick, radial in the middle and convergent at the ends.

This species resembles *P. stauroptera* Grun., described and illustrated by Berg. (Berg., *Diat. Sophia-Exped.*, 1945, 17, t. 5, f. 175) and Cleve-Euler [Cleve-Euler, *Diat. Schwed. Finn.*—IV, 1955, 67, f. 1091 *d–e* (= *P. stauroptera* v. *clevei* Meister)], in having acutely-wedge-shaped capitate ends, but in no other details. There are no other similar forms known from the literature, hence it is considered tentatively as a new species.

This species was collected from pools and ditches in the rivulet where it occurred in brownish masses of matter, in a small number. Some stray specimens also were recorded from Podostemad encrustations. It is rare in the locality. Slide no. 752.

18. *Pinnularia cardinaliculus* (Cl.) Lund.

(Text-Fig. 20)

Lund, J. W. G., *Brit. Alg.*, 1950, 281–84, f. 1 A–I: Valves 72·2–90 μ long and 12·2–15 μ broad, linear with very weakly inflated middle part and broadly rounded ends. Raphe slightly thickened and straight with central pores unilaterally bent and terminal fissures clearly curved, bayonet-shaped. Axial area fairly wide, $\frac{1}{4}$–$\frac{1}{3}$ the width of the valve; central area quite large reaching the sides. Striæ 8–9 in 10 μ, thick

with faint narrow longitudinal band, radial in the middle and convergent at the ends.

This species was seen in pools and puddles in the rivulet along with the above type. It occurred either singly or in short catenate colonies formed in pale brown matter (probably a benthos of the loose soil). A few stray specimens were also recorded from a pond. Sparingly distributed in the locality. It is also recorded from the Jog-falls.

19. *Pinnularia angustefasciata* A. Cl.

(Text-Fig. 21)

The specimens recorded from this region are somewhat broader (17·6 μ broad) than those recorded from Mugad. Also the apices are more clearly cuneate.

20. *Pinnularia mysorense* sp. nov.

(Text-Fig. 18)

Valvæ 82·5–110 μ longæ atque 15·6–18 μ latæ, lineares, paulum dilatata in medio, apicibus late rotundata. Raphe crassa, distincte complexa, ornata poris centralibus unilateraliter inclinata ac fissuris terminalibus crassa ac semicirculares. Area axialis lata, $\frac{1}{4}$–$\frac{1}{3}$ latitudinis valva; area centralis ampla, parva versus ad margines perveniens. Striæ 7–8 in 10 μ, crassa, radiales in medio ac convergentes in utroque apice, evoluta vittæ longitudinalibus angusta cum languida.

Valves 82·5–110 μ long and 15·6–18 μ broad, linear with slightly dilated middle part and broadly rounded ends. Raphe thick, clearly complex with central pores unilaterally bent and terminal fissures thick and clearly semicircular. Axial area fairly large, $\frac{1}{4}$–$\frac{1}{3}$ the width of the valve; central area large but narrowly reaching the sides. Striæ 7–8 in 10 μ, thick, radial in the middle and convergent at the ends, longitudinal bands present, narrow and faint.

This species resembles *P. hartleyana* Grev. (Mills, *Diat. Warri*, 1932, 390, pl. 2, f. 17), in the outline, but greatly differs in dimensions (230–66 × 30–37 μ and striæ ?). Moreover, the raphe is not indicated to be complex due to which the comparison is difficult. Another similar looking species is *P. rivularis* Hust. [Hustedt, *Diat. Tobasees Sumatra*, 1936, 160, t. 5, f. 35 (dimensions 70–85 × 10–12 μ, striæ 9 in 10 μ); *Diat. Sunda-Exped.*, 1938, 393, t. 23, f. 3; *Diat. Wallacea-Exped.*, 1942, 207, f. 166, which agrees in the outline and somewhat in range of dimensions of the present diatom. However, the present forms have distinctly complex raphe and closely set striæ having longitudinal bands though narrow and faint. Hustedt does not indicate such a kind of raphe in his specimens from the Sunda-expedition and Sumatra material, but his Indo-Malayan forms are shown to have thick simple raphe. Moreover, *P. rivularis* is being referred to the "Distantes" group, which suggests and shows the striæ to be very thick or distantly set from one another. In these characters the present specimens differ.

Further, they do not show any closeness with any other species of *Pinnularia*, hence they are considered to be a new species.

This species was collected from pools and puddles in the rivulet where it occurred in brownish masses of dead vegetable matter in a good number. A few stray or isolated specimens also were recorded from Podostemad encrustations and a pond. Slide no. 755.

21. *Amphora ovalis* Kütz. v. *affinis* Kütz.

(Text-Fig. 40)

Van Heurck, *Treat. Diat.*, 1896, 127, pl. 1, f. 17; Jurilj, *Diat. Ochrida Lake*, 1954, 147, f. 56 *c*: Frustules 44–56 μ long and 22–24 μ broad, linear-elliptical with truncate ends in girdle view. Valves 6–6·5 μ broad, lunate with ventral side slightly inflated in the middle and narrowed rounded ends. Raphe thin, arcuate with central pores reflexed towards the dorsal side in a graceful arc, terminal fissures ventrally bent. Axial area very narrow; central area large, reaching the ventral side, on the dorsal side quadrate, bounded by striæ. Striæ 14–16 in 10 μ, radial on the dorsal side and on the ventral side radial in the middle and convergent at the ends, striæ clearly lineate, lineations irregularly arranged due to which several longitudinal lines of irregular nature appear evidently.

This diatom was collected from a pond in good number, but it was more frequent in pools and puddles in the rivulet embedded in brownish masses of matter. It is probably a benthos of the loose soil. Its range of distribution found up to the Jog-falls. It is also recorded from Kolhapur.

22. *Cymbella amphicephala* Naeg.

(Text-Fig. 41)

Hustedt, *Bacil.*, 1930, 355, f. 651; Voigt, *genre Cymbella*, 1943, 6, pl. 1, f. 11; Cleve-Euler, *Diat. Schwed. Finn.*—IV, 1955, 151, f. 1223 *a–b* (= *C. amphicephala* v. *genuina* Mayer): Valves 30–34 μ long and 8–8·5 μ broad, asymmetrical, semilanceolate, ventral side slightly convex in the middle, ends constricted and produced capitate. Raphe thin and very straight and terminal fissures dorsally bent. Axial area very narrow; central area very small. Striæ 13–14 in 10 μ on the dorsal side and 14–16 in 10 μ on the ventral side, very slightly radial and not at all coarsely, clearly punctate.

This species has been described in the Indian literature, but for the certain obvious reasons it has been redescribed and illustrated.

23. *Cymbella affinis* Kütz.

(Text-Fig. 42)

Hustedt, *Bacil.*, 1930, 362, f. 671; Skvortzow, *Diat. Kizaki Lake*, 1937, 49, pl. 11, f. 9–10; Cleve-Euler, *Diat. Schwed. Finn.*—IV, 1955, 158, f. 1242: Valves 35–38 μ long and 10–11 μ broad, asymmetrical,

dorsal side highly convex, ventral side slightly convex; ends constricted, rostrate to subcapitate. Raphe slightly thick, arcuate with terminal fissures dorsally bent. Axial area narrow, sublinear; central area distinct with a stigma on the ventral side. Striæ 10–14 in 10 μ, radial, distinctly punctate, striæ somewhat closer at the ends.

This species was collected from some pools and puddles in the rivulet where it occurred in brownish masses of dead vegetable matter. A few stray specimens were also seen in other samples. Not common in the area.

24. *Cymbella javanica* Hustedt

(Text-Fig. 22)

Hustedt, *Diat. Sunda-Exped.*, 1938, 424, t. 25, f. 1–3: Valves 13–18 μ long and 4–4·5 μ broad, asymmetrical with more strongly convex dorsal side than the ventral side, ends constricted, somewhat produced, rounded and ventrally bent. Raphe thin and straight with small terminal fissures. Axial area quite narrow; central area little expanded. Striæ 11–13 in 10 μ, radial and somewhat closely set at the ends.

This species was found abundantly growing in several pools and puddles in the rivulet as benthos of the loose soil. In Podostemad encrustation it seemed to form thin films of pale brown hue (benthos —lithophilous). Well distributed in the area and up to the Jog-falls.

25. *Cymbella japonica* Reichelt

(Text-Figs. 23, 43)

Skvortzow, *Diat. Kizaki Lake*, 1937, 49, pl. 10, f. 4; pl. 11, f. 1, 7; Hustedt, *Diat. Sunda-Exped.*, 1938, 419, t. 25, f. 20; Fukushima, *Diat. Oze*, 1954, 613, f. 6 C: Valves 38·5–46 μ long and 10–12 μ broad, subsymmetrical, lanceolate, dorsal side slightly more convex than the ventral, ends acute to obtusely rounded. Raphe thick, slightly arcuate with central pores ventrally bent and terminal fissures dorsally directed. Axial area moderately wide, lanceolate; central area fairly large, more widened on the ventral side with an isolated stigma. Striæ 7–8 in the middle on the dorsal side otherwise 9–10 in 10 μ, coarse and clearly lineate, radial throughout or probably perpendicular to the middle line towards the ends.

This species was collected in abundance from all the region from Sagar to the Jog-falls. It mostly occurred in encrustations formed by Podostemads, mosses and liverworts growing on wet rocks. It is mostly a lithophilous benthos. It is so far known from Japan, Java, Bali and Sumatra Islands. Its find in Indian region makes extension of the geographical distribution.

26. *Cymbella sagarensis* sp. nov.

(Text-Figs. 24–25)

Valvæ 19–38 μ longæ atque 8·8–10 μ latæ, subsymmetrice, margine dorsali plusculum convexo quam ventrali, in medio paulum recta;

apicibus abrupte constrictis, brevi-rostrato, acuto-rotundatæ. Raphe tenuis vel crassa, leniter centrica, poris centralibus ventrali inclinata, fissuris terminalibus ad marginem dorsalem versus flexis. Area axialis lata, linearis; area centralis latere ventrali dilatata cum uno punctum distincta. Striæ 8–10 in 10 μ, aliquantum radiales ac distincte lineatæ.

Valves 19–38 μ long and 8·8–10 μ broad, subsymmetrical, dorsal side slightly more convex than the ventral, somewhat straight in the middle with abruptly narrowed, shortly rostrate, acutely rounded ends. Raphe thin or coarse, slightly arcuate and almost central. Axial area fairly wide, linear; central area on the ventral side dilated with a distinct stigma. Striæ 8–10 in 10 μ, slightly radial and distinctly lineate.

This species appears to be a distinctive one and does not agree with any similar looking forms in the literature. It is, therefore, considered to be a new species.

This species was collected from a large number of pools, puddles and ditches in the rivulet. It also occurred in encrustations formed by Podostemads and some Myxophyta. In other bodies of fresh-water, it occurred but in smaller numbers. Well represented in the area and also recorded from the Jog-falls. It is probably a benthos of the loose soil as well as of the rocks and stones. Slide no. 756.

27. *Cymbella sagarensis f. gracilis f.* nov.

(Text-Fig. 44)

Valvæ 33–35 μ longæ atque 8·8–9 μ latæ, subsymmetrice, elliptico-lanceolatæ, apicibus paulum constrictis, rostratis. Striæ 8–9 in 10 μ radiales ac distincte lineatæ. In coeteris ut typus.

Valves 33–35 μ long and 8·8–9 μ broad, subsymmetrical, elliptical-lanceolate with slightly constricted rostrate ends. Striæ 8–9 in 10 μ radial and distinctly lineate. In all other details like the type.

This diatom is a graceful looking one on account of a smooth dorsal arch. It was collected along with the above type but in a smaller number. Slide no. 756–57.

28. *Cymbella aspera* (Ehr.) Cl.

(Text-Fig. 45)

Length 90–170 μ, breadth 24–30 μ, striæ 7–9 in 10 μ and the punctæ of the striæ 13–15 in 10 μ.

The form illustrated in my paper on Partabgarh Diatoms, is probably *C. bengalensis* Grun. (Voigt, *genre Cymbella*, 1943, 11, pl. 2, f. 1; Skvortzow, *Diat. Philippines*, 1937, 292, pl. 2, f. 9). This I refer to, because the ventral side is distinctly more or less uniformly convex and it has comparatively finer punctæ of the striæ. The other specimens collected from this region agree well with illustration given by Cleve-Euler [Cleve-Euler, *Diat. Schwed. Finn.*—IV, 1955, 166, f. 1256 *a–c* (= *C. aspera* v. *genuina* A. Cl.) and Iyengar and Subrahmanyan (= *Fossil Diat.*, 1943, 232, f. 25–26)] for *C. aspera*.

The illustration, which I presently give for *C. aspera*, shows a strong resemblance with *C. aspera* v. *elongata* Skv. (Skovrtzov, *Diat. N. Manchuria*, 1928, 46, pl. 4, f. 4) (dimensions: 192–340 × 37–45 μ, striæ 8–9 in 10 μ and punctæ 12–15 in 10 μ), on account of a strong inflation on the ventral side which appears quite out of line connecting the apices. Thus, the form agrees well with *C. aspera* v. *elongata* Skv., except for the dimensions. However, I refer this illustrated form to *C. aspera* only, because of the paucity of the material.

29. *Cymbella rivularis* sp. nov.

(Text-Fig. 26)

Valvæ 68–102 μ longæ atque 22–26 μ latæ, asymmetrice, margine dorsali valde convexa, ventrali inflata, recta vel paulum convexa cum leniter sed distincte triundulata; apicibus constrictæ ac brevi-rostrato-subtruncatæ. Raphe crassa, arcuata, excentrica vel leniter excentrica, poris centralibus distincte ventrali inclinata, fissuris terminalibus ad marginem dorsalem versus flexis. Area axialis modice, sublinearis; area centralis paulum unilateraliter dilatata. Striæ latere dorsali 8–9 in 10 μ in medio ac in utroque apice 9–11 in 10 μ, striæ latere ventrali 9–10 in medio ac 10–12 in 10 μ in utroque apice, ubique radiales, clare punctatæ, punctis 16–18 in 10 μ, punctæ latere dorsali crassa quam latere ventrali.

Valves 68–102 μ long and 22–26 μ broad, asymmetrical, dorsal side strongly convex and ventral side inflated, straight or slightly convex with feeble but distinct triundulations; ends constricted, shortly rostrate and truncate. Raphe thick, arcuate, excentric to slightly excentric with central pores distinct and ventrally bent and terminal fissures dorsally bent. Axial area moderate, sublinear; central area slightly unilaterally widened. Striæ on the dorsal side 8–9 in 10 μ in the middle and 9–11 in 10 μ at the ends, on the ventral side 9–10 in the middle and 10–12 in 10 μ at the ends, radial throughout, clearly punctate, punctæ 16–18 in 10 μ, punctæ of the dorsal side coarser than the ventral one.

This species does not agree with any known species of *Cymbella*, hence it is considered to be a new species.

This species was collected in a good number from pools and puddles in the rivulet. It also occurred in encrustations formed by Podostemads and some Myxophyta. In a pond it was seen as a stray form. Common in the region. For its coarser structure and robustness it appears like *C. aspera* (Ehr.) Cl. Slide no. 759.

30. *Gomphonema acuminatum* Ehr. v. *directum* A. Cl.

(Text-Fig. 27)

Cleve-Euler, *Diat. Schwed. Finn.*—IV, 1955, 174, f. 1262 *z-å*: Valves 28–34 μ long and 5·5–6 μ broad, lanceolate-clavate with acute ends. Raphe thin and straight. Axial area linear; central area small, slightly

unilateral with an isolated stigma. Striæ 10–12–14 in 10 μ, fine and radial.

This diatom was collected in a small number from some of the pools in the rivulet. It occurred in brownish matter with other forms.

31. *Gomphonema intricatum* Kütz. v. *vibrio* (Ehr.) Cl.

(Text-Fig. 46)

This diatom is being described by a previous worker, but specimens collected from this area show a wider range of dimensions (length 90–110 μ, breadth 10·3–12 μ and striæ 7–8 in the middle up to 10 in 10 μ at the ends). The specimens are more linear-clavate with a sharply defined median gibbosity than those previously illustrated. Some of the specimens of which an illustration is given tended to show somewhat obtusely-cuneate apex. This illustration more or less agrees with that of Cleve-Euler's.

32. *Gomphonema lanceolatum* Ehr. *f. turris* (Ehr.) Hust.

(Text-Fig. 47)

Hustedt, *Diat. Tobasees Sumatra*, 1936, 166, t. 3, f. 323 (= *Gomphonema lanceolatum* f. *turris* Ehr. n. comb.); *Diat. Sunda-Exped.*, 1938, 437, t. 26, f. 8–11 [= *G. lanceolatum* f. *turris* (Ehr. e.p.) Hust.]: Valves 67–73·7 μ long and 11–12·2 μ broad, lanceolate-clavate with slightly constricted, broadly wedge-shaped apex and attenuated base. Raphe thin and straight. Axial area sublinear; central area quite large, unilaterally expanded with an isolated stigma on the opposite side. Striæ 9–10 in 10 μ, clearly punctate and radial.

This diatom was collected in a small number from a pond and some ditches but in a good number from the rivulet. It occurred in brownish masses of decaying vegetable matter. Fairly distributed in the locality.

33. *Gomphonema tropicale* Brun.

(Text-Fig. 28)

Skvortzow, *Diat. Chengtu*, 1938, 491, pl. 1, f. 1–5, pl. 2, f. 10: Valves 68–80 μ long and 9–10 μ broad, narrowly lanceolate-clavate, apices broadly rounded. Raphe thick with fissures in the central nodule transversely common-shaped and terminal fissures distinct. Axial area linear; central area large, unilaterally reaching the side, on the opposite side 2–4 stigmas present one at an end of every middle striæ. Striæ 5–7 in the middle and 6–9 in 10 μ at the ends, radial and clearly lineate.

This species was collected in a small number from pools and puddles in the rivulet. It was found mixed up in decaying vegetable matter. Some samples of Podostemad encrustations also yielded it but as a stray form. Not common in the locality.

34. *Gomphonema clevei* Fricke

(Text-Fig. 48)

Hustedt, *Diat. Sunda-Exped.*, 1938, 441, t. 27, f. 15–18; Fukushima, *Diat. Oze*, 1954, 614, f. 5 G; Skvortzow, *Diat. Kizaki Lake*, 1937, 51, pl. 13, f. 33, 40 (= *G. vastum* Hust. v. *elongata* Skv.); Gandhi, *Diat. Hirebhasgar*, 1958, 261, f. 20 (= *G. vastum* v. *elongata* Skv.): Length 20–40 μ, breadth 4·5–5·5 μ and striæ 13–16 in 10 μ.

While going through the literature which has been available lately, I consider Skvortzow's *G. vastum* v. *elongata* to be *G. clevei* Fricke, this also renders correction of my so described specimens from the Hirebhasgar-dam area. Skvortzow probably based his new variety on the basis of *G. vastum* Hust. (Hustedt, *Bacil. Aokikosee*, 1927, 166, t. 5, f. 4), which has short marginal striæ and large axial area, and Skvortzow's form differing from it in not possessing capitate apex.

35. *Gomphonema clevei* v. *bipunctata* v. nov.

(Text-Fig. 49)

Valvæ 36–44 μ longæ atque 6–6·5 μ latæ, lanceolatæ-clavatæ, ad basim leniter productis ac rotundatis. Raphe tenuis et recta. Area axialis late-lanceolata; area centralis indistincta sed duplici stigmata evoluta. Striæ 16–17 in 10 μ, ut in typus.

Valves 36–44 μ long and 6–6·5 μ broad, lanceolate-clavate with somewhat narrowed, produced rounded base. Raphe thin and straight. Axial area broadly lanceolate; central area not defined but with two stigma. Striæ 16–17 in 10 μ, as in the type.

This diatom differs from the type in having lanceolate-clavate outline with somewhat produced ends and two stigma in the central area.

This form was collected in a very small number along with the type from Podostemad encrustations. Rather rare in the locality. Slide no. 761.

36. *Nitzschia pseudogracilis* sp. nov.

(Text-Fig. 51)

Valvæ 70–82·5 μ longæ atque 4·5–5 μ latæ, tenui-lanceolatæ, apicibus tenui-rostratæ ac brevi-capitatæ. Carina ex-centro, carina punctæ 11–12 in 10 μ, minuta. Striæ circiter 35 in 10 μ, tenues atque indistincte.

Valves 70–82·5 μ long and 4·5–5 μ broad, narrowly lanceolate, ends narrowly produced and shortly capitate. Keel excentric, keel punctæ 11–12 in 10 μ, small. Striæ about 35 in 10 μ, fine and indistinct.

This species resembles *N. gracilis* Hantz. (Hustedt, *Bacil.*, 1930, 416, f. 794), in narrowly produced, slightly capitate ends and somewhat in range of dimensions. However, the local specimens have clearly lanceolate outline, greater breadth, keel punctæ fewer in number, hence they differ. With *N. obsidialis* Hust. (Hustedt, *Diat. Albert-Nationalpark*, 1949, 148, t. 13, f. 25), it strongly resembles in the outline but differs in dimensions, number and organisation of keel punctæ. With these observed differences, the present specimens are tentatively considered to be a new species.

This species was seen in a good number in collections mostly made from pools and puddles in the rivulet. It occurred in brownish masses of decaying vegetable matter. A few samples from other wet situations also yielded it but sparingly. Fairly common in the locality. It is a benthos of the loose soil as understood from its habitat. Slide no. 763.

37. *Surirella linearis* W. Sm.

(Text-Fig. 29)

Hustedt, *Bacil.*, 1930, 434, f. 837; Cleve-Euler, *Diat. Schwed. Finn.* —V, 1952, 109, f. 1535 *a–b* (= *S. linearis* v. *genuina* A. Cl.): Valves 82–110 μ long and 20–25 μ broad, linear with cuneate ends. Axial field somewhat narrow, linear-lanceolate. Flap margin narrow but with clear falp projections. Costæ 22–24 in 100 μ.

This species is being described by a previous worker from India, but the differences found in the local forms happen to be gross than the recorded ones, hence the need for description and reillustration was felt. The present species very closely agrees with Hustedt's and Cleve-Euler's specimens.

38. *Surirella celebesiana* Hust.

(Text-Fig. 30)

Hustedt, *Diat. Wallacea-Exped.*, 1942, 161, f. 403–6: Valves 75–80 μ long and 26–28 μ broad, heteropolar, subovate with cuneate rounded ends, apex somewhat broader than the base. Axial field narrowly lanceolate with a median line. Marginal folds not very clear, flap projections also not clear. Costæ 28–32 in 100 μ, strongly radial at the apices, striæ indistinctly punctate and the punctæ irregularly disposed.

The species collected from this region shows somewhat more cuneate apex and apparent heteropolar nature. In all other details it agrees very closely with the type.

This species was seen as a stray form in some collections from pools and puddles in the rivulet. Rare in the locality.

39. *Surirella horrida* Hust. *f. minor f.* nov.

(Text-Fig. 31–32)

Valvæ 55–74·8 μ longæ atque 24–28 μ latæ, paulum heteropolares, ovatæ-elliptice, apice late-rotundatis, basi late subcuneatis. Area axialis angustissima. Rugæ marginales angusta fere non-clara, rugæ projectionibus marginata. Costæ 16–19 in 100 μ, paulum radiales in utroque apice. Costæ marginibus aculeatæ vel punctatæ. Striæ circiter 8–9 in 10 μ, tenues sed distincte.

Valves 55–74·8 μ long and 24–28 μ broad, slightly heteropolar, ovate-elliptical with broadly rounded apex and broad subcuneate base. Axial field very narrow. Flap margin narrow, almost indistinct, flap projections marginal. Costæ 16–19 in 100 μ, slightly radial at the apices. On the margin of the costæ some points or prickles present. Striæ 8–9 in 10 μ, fine but distinct.

This diatom collected from the area resembles well with *S. horrida* Hust. (Hustedt, *Diat. Wallacea-Exped.*, 1942, 157, f. 394–5) in practically all the characters, except that it is much smaller in dimensions. A similar form is described by Skvortzow as *S. margaritifera* Hust. (Skvortzow, *Diat. Baikal Lake*, 1937, 358, pl. 16, f. 5, pl. 17, f. 2), of which two illustrations given are quite different in their outlines, but the present ones agree with "Fig. 2 on Pl. 1". However, the present form is not referred to Skvortzow's type, since the dimensions are not known. Moreover, the striæ observed in the local specimens are definitely very few in number.

This diatom was collected in a good number from pools and puddles in the rivulet and also from Podostemad encrustations. From the collections it appears that it is primarily a benthos of the loose soil and secondarily a lithophilous one. Fairly distributed in the area. Slide no. 764.

40. *Surirella capronioides* sp. nov.

(Text-Fig. 52)

Valvæ 96·8–104 μ longæ atque 40·7 μ latæ, heteropolares, ovatæ, basi cuneatæ. Area axialis anguste-lanceolata cum linea media ubique interrupta ad terminalibus spinosa. Rugæ marginales evoluta cum projectionibus distincta. Costæ 18–20 in 100 μ, valde, radiales in utroque apice, clare lineares ut in *S. capronii* Bréb., striæ tenues, indistincte.

Valves 96·8–104 μ long and 40·7 μ broad, heteropolar ovate with cuneate base. Axial field narrowly lanceolate with a middle line interrupted throughout and beset with spines at both ends. Flap marginal with clear flap projections. Costæ 18–20 in 100 μ, strong, radial at the ends, clearly linear as seen in *S. carponii* Bréb., striæ fine and indistinct.

This species is being described in an earlier paper on Partabgarh Diatoms (Gandhi, *Diat. Partabgarh*, 1955, 335, f. 53) as *S. tenera* v. *splendidula* A.S., but with close comparison and observation it seems to differ from it in several respects, except for the outline. Firstly, the middle line has distinct spines at both the ends, axial field clearly defined and narrowly lanceolate, dimensions quite large and the costæ well marked which are gracefully linear with truncate ends. In all these features it closely agrees with *S. carponii* Bréb. However, it differs from *S. carponii* (Hustedt, *Alg. Bremen*, 1909, 450, f. 11–12; *Bacil.*, 1930, 440, f. 857), in being smaller in dimensions with larger number of costæ. Moreover, the apex is much broader than in *S. capronii* due to which the present forms appear clearly wedge-shaped. Further, the spines at either end of the median line are not formed on elevated cushions. These differences appear to be quite large from that of *S. capronii*, hence, the present specimens are considered to be a new species, including *S. tenera* v. *splendidula* A.S. of my paper on Partabgarh Diatoms. Slide no. 766.

Summary

For the first time the Diatom flora of Sagar in Mysore State has been explored and an illustrated account is presented in these pages.

From the examination of these diatoms several interesting aspects are unfolded. The flora is essentially tropical in nature and it is comparable with that of Java, Bali, Sumatra and Indo-Malayan region. The range of geographical distribution of some of the species is extended. The fact which can be derived from the present investigation is that the Western Ghats region abounds in diatoms and is likely to yield an extremely rich harvest if extensive explorations are carried out.

In this paper some of the diatoms are readjusted with the availability of the fresh-literature. Under the individual species, some notes on ecology, occurrence and distribution of the same, are also given.

From this area, in all 74 diatoms have been recorded representing 16 genera. Of these, 15 are new records for India and 8 species, 2 varieties and 2 forms are considered to be new for the Science.

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References

Berg, Å. 1945. Diatomeen von der Sophia-Expedition in Jahre 1883, *Ark. Bot.* **32 A** (1): 1–34.

Cleve-Euler, A. 1951–55. Die Diatomeen von Schweden und Finnland—I, V II, III, IV. *K. Svenska Vetens. Acad. Handl.* Fjärde Ser. **2** (1): 1–163; **3** (3): 1–153; **4** (1): 1–158; **4** (5): 1–255; **5** (4): 1–232.

DONKIN, A. S. 1871–73. *The Natural History of the British Diatomaceæ*, Pts. I–III, pls. 1–12, pp. 1–74, London.

FOGED, N. 1957. 1. Diatoms from Rennell Island. *Natur. Hist. Rennell Isl., Brit. Solomon Isl.* **3**: 6–117.

FUKUSHIMA, H. 1954. Diatom Flora of Oze. *Sci. Resear. Ozegahara Moor.* **1954**: 602–21.

GANDHI, H. P. 1955. A contribution to our knowledge of the fresh-water Diatoms of Partabgarh, Rajasthan. *J. Indian bot. Soc.* **34**: 307–38.

———. 1956 *a*. A contribution to our knowledge of fresh-water Diatomaceæ of South-Western India. I. Fresh-water Diatoms of Dharwar. *Ibid.* **35**: 194–209.

———. 1956 *b*. A preliminary account of the soil Diatom-flora of Kolhapur. *Ibid.* **35**: 402–8.

———. 1957 *a*. The fresh-water Diatoms from Radhanagari—Kolhapur. *Ceylon J. Sci.* (*Biol. Sect.*) **1**: 45–57.

———. 1957 *b*. Some common fresh-water Diatoms from Gersoppa-Falls (Jog-falls). *J. Poona Univ.* (*Sci. Sect.*) **1957**: 13–21.

———. 1957 *c*. A contribution to our knowledge of the Diatom genus '*Pinnularia*'. *J. Bom. nat. Hist. Soc.* **54**: 845–52.

———. 1958 *a*. Fresh-water Diatom-flora of the Hirebhasgar-Dam area—Mysore State. *J. Indian bot. Soc.* **37**: 249–65.

———. 1958 *b*. Fresh-water Diatoms from Kolhapur and its immediate environs. *J. Bom. nat. Hist. Soc.* **55**: 493–511.

GONZALVES, E. A. AND GANDHI, H. P. (1952–54). A systematic account of the Diatoms of Bombay and Salsette. Pts. I–III. *J. Indian bot. Soc.* **31**: 117–51; **32**: 239–63; **33**: 338–50.

HUSTEDT, F. 1909. Beiträge zur Algenflora von Bremen. II. Die Bacillariaceen-vegetation des Torfkanals. *Abh. naturw. Ver. Bremen.* **19**: 419–52.

———. 1927. Bacillariales aus dem Aokikosee in Japan. *Arch. Hydrobiol.* (*u. Planktonk.*) **18**: 155–72.

———. 1930. *Bacillariophyta* (Diatomeæ) in A. Pascher's *Die Süsswasserflora Mitteleuropas*. **10**: Jena.

———. 1936. Die Fossile Diatomeenflora in den Ablagerungen des Tobasees auf Sumatra. *Arch. Hydrobiol.* (*u. Planktonk.*) Suppl. **14**: 143–92.

———. 1938. Systematische und ökologische Untersuchungen über die Diatomeen-Flora von Java Bali und Sumatra nach dem Material der Deutschen Limnologischen Sunda-Expedition. *Ibid.* **15**: 131–77; 187–295; 293–506; 638–790.

———. 1942. Süswasser-Diatomeen des indomalayischen Archipels und der Hawii Inseln. nach dem Material der Wallacea-Expedition. *Int. Rev. Ges. Hydrobiol. Hydrogr.* **42**: 1–252.

——— 1949. Süsswasser-Diatomeen aus dem Albert-Nationalpark in Belgisch-Kongo. *Expl. Parc nat.-Albert Miss. H. Damas.* 1935–36, **8**: 1–199.

———. 1950. Die Diatomeenflora norddeutscher Seen mit besonderer Berücksichtigung des holsteinischen Seengebiets. *Arch. Hydrobiol* (*u. Planktonk.*) **43**: 329–458.

IYENGAR, M. O. P. AND SUBRAHMANYAN, R. 1943. Fossil Diatoms from the Karewa Beds of Kashmir. *Proc. nat. Acad. Sci., India* **13**: 225–36.

JURILJ, A. 1954. Flora and vegetation of Diatoms from Ochrida Lake in Jugoslavia. *Jugoslav. Akad. Znan. Umjet.* **1954**: 99–190.

LUND, J. W. G. 1950. Contributions to our knowledge of British Algæ. *Hydrobiologia* **2**: 281–84.

MILLS, F. W. 1932. Some Diatoms from Warri, South Nigeria. *J. roy. microsc. Soc.* **52**: 383–94.

PATRICK, R. 1948. Factors effecting the distribution of Diatoms. *Bot. Rev.* **14**: 473–524.

SVKORTZOW, B. W. 1928. Diatoms from Khingan, North Manchuria. *Philipp. J. Sci.* **35**: 39–51.

————. 1937 *a*. Diatoms from Kizaki Lake, Honshu Island, Nippon. *Ibid.* **61**: 9–73.

————. 1937 *b*. Diatoms from Biwa Lake, Honshu Island, Nippon. *Ibid.* **61**: 253–96.

————. 1937 *c*. Diatoms from Olhan Gate of Baikal Lake, Siberia. *Ibid.* **62**: 293–377.

————. 1937 *d*. Diatoms from the Philippines—I. Diatoms from drinking water, Balara Rizal Province. *Ibid.* **64**: 287–98.

————. 1938 *a*. Fresh-water Diatoms from environs of Vladivostok. *Ibid.* **65**: 251–61.

————. 1938 *b*. Diatoms from Chengtu, Szechwan, Western China. *Ibid.* **66**: 479–96.

TIFFANY, L. H. AND BRITTON, M. E. 1952. *The Algæ of Illinois*. Univ. Chicago Press, Chicago.

VAN HEURCK, H. 1836. *A Treatise on the Diatomaceæ* (translated by W. E. Baxter), London.

VENKATARAMAN, G. 1939. A systematic account of some South Indian Diatoms. *Proc. Indian Acad. Sci.* **B 10**: 293–368.

————. 1956. *Contributions to Our Knowledge of Fresh-water Diatoms of South India*. Government Press, Madras, 1956: 1–20.

VOIGT, M. 1943. Note sur quelques espèces Chinoises du genre *Cymbella*. *Not. Bot. Chin.* Muèse Heude. **1943** (5): 1–46.

A HISTORY OF THE GENUS *PYCNOLEJEUNEA* (SPR.) SCHIFFN.

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A proper understanding of the generic limits of *Pycnolejeunea* appeared to be in a mess till recently. Spruce (1884–85, p. 246–47) was the first to treat this group as a subgenus under his portmanteau genus *Lejeunea*, basing it on the type "*L. contigua* N". Unfortunately Spruce's "*L. contigua*" proved to be unrelated to *L. contigua* Nees; consequently Schiffner (1897, p. 583) renamed *L. contigua* Spruce nec Nees as *Pycnolejeunea spruceana* and this species deserves the recognition as the genotype of this genus. Spruce recognized 2 species under his subgenus *Pycno-Lejeunea*, namely, "*L. contiguan* and *L. macroloba* Mont.; and observed: "Affinitatem habet cum *Euosmo-Lejeunea*, ex odore leniter suavi et foliolis majusculis, longe diversa tamen habitu, foliis confertissimus pellucidissimus, etc.; etiam cum *Trachy-Lejeunea* e foliis papillosis interdum ocellatis, a qua distat foliis prælatis confertissimis, foliolis multo majoribus, perianthiis lævibus, etc. *Cheilo-Lejeunea* statura minore, cellulis obscuris (e chrolophylli annulo opaco) et perianthiis compressis demum bilabiatis magis remota est".

Schiffner (1893, p. 124) raised Spruce's subgenus to a generic rank but preferred *P. macroloba* (Mont.) Spr. ex Schiffn. ås the type. However, he did not assign any reasons for this change.

Evans (1906) remarked that the derivation of a genotype for *Pycnolejeunea* was rather difficult, but suggested that *P. spruceana* Schiffn. deserved this rank. He clearly and lucidly delimited this genus and discussed briefly its relationships with *Cheilolejeunea* and *Rectolejeunea*.

Even with a classic diagnosis of this genus as given by Spruce himself and later by Evans, majority of workers on this genus seem to have failed to estimate the limits of this genus. Stephani (1914) was the first who added to the confusion by describing such wholly unrelated taxa as *P. angulistipa*, *P. pilifera*, *P. schiffneri* and a number of other "*Pycnolejeunea*" species under his *Pycnolejeunea*! A recent paper (Hoffmann, 1935) which was supposed to be a monograph for the Indo-Malayan region includes *very few real Pycnolejeuneas*! It is regretted that even Herzog 'fell' to this 'game' and described a few completely unrelated taxa under *Pycnolejeunea*.

In a recent study Kachroo and Schuster (1958) discussed the enormous confusion that existed in the taxonomy of this genus and also its affinities with *Cheilolejeunea*, *Euosmolejeunea*, *Nipponolejeunea*, *Tuyamælla*, *Siphonolejeunea* and *Strepsilejeunea*: genera with which *Pycnolejeunea* has been confused in the extant literature. They recog-

nized *P. spruceana* Schiffn. as the genotype; and found that *Pycnolejeunea* s. lat. was really an aggregate of three different categories, namely, (*a*) taxa with *proximal* hyaline papilla; (*b*) taxa with *distal* hyaline papilla; and (*c*) taxa with *entally* displaced hyaline papilla. The first category is represented by *Pycnolejeunea* s. str.; the second by *Cheilolejeunea* subg. *Xenolejeunea* and the third by three discrete genera: *Nipponolejeunea*, *Tuyamælla* and *Siphonolejeunea*! The following key gives the main characteristics of each genus.

1. Lobe and lobule *longly inserted on the axis*, lobuli with a *single apical tooth*, the hyaline papilla *marginal*; asexual reproduction by means of discoid gemmæ absent. 2

    2. The hyaline papilla *proximal* of the apical tooth, the latter one-celled, blunt or occasionally acute; lobuli various always inflated, obovate, elongate-lingulate or ovate and greatly inflated or utriculate and inflated and dilated throughout; leaves densely imbricate, apex usually rounded, rarely apiculate, deflexed; usually with ocelli; underleaves normally broader than long, usually densely imbricate; stem anatomy various; the perianth usually compressed with sharp keels, rarely terete; microphyllous shoots often developed; caducous leaves never developed. .. .. *Pycnolejeunea*

    2. The hyaline papilla *distal* of apical tooth; lobuli narrow and slender with a prominent apical tooth formed of hardly or moderately elongated cells, 2-several cells long, the hyaline papilla thus situated 2-several cells below the actual apex of lobule; leaves with lobes broadly rounded at apex; underleaves small to remote; leaves and underleaves not densely imbricate; usually without ocelli; stem anatomy normally schizostipous, rarely holostipous with the ventral merophytes 3–4 cells wide; perianths often with the antical keel low and broad or vestigial, the postical carinæ often obtuse and coalescent; microphyllous shoots never developed. .. .. *Cheilolejeunea* subg. *Xenolejeunea*[1]

1. Lobe and lobule *very narrowly inserted on the axis*; lobuli with apical tooth either undefined or bidentate; the hyaline papilla (marginal) terminal or entally displaced; asexual reproduction when present, *via* discoid gemmæ. 3

    3. Lobuli *bidentate*, the hyaline papilla *entally displaced*, situated under the base of the apical tooth. 4

        4. Perianth sharply tricarinate; female bracts with strongly convex rigid keel; leaf margins, at least locally, developing long uniseriate cilia; leaf cells without coarse trigones; underleaves subrotundate, slightly

[1] Kachroo and Schuster (1958) recognize three subgenera under *Cheilolejeunea*, namely, *Cheilolejeunea*, *Euosmolejeunea* and *Xenolejeunea*.

emarginate; asexual reproduction unknown; stem anatomy holostipous; cortical cells in *c.* 24 rows, small, thick-walled, the ventral merophytes *c.* 8 cells wide. .. .. .. *Nipponolejeunea*

4. Perianth basically 5-carinate; female bracts without a strong keel; leaf margins never developing cilia; asexual reproduction *via* discoid gemmæ; underleaves with lobes suberect to slightly divergent, blunt to rounded at apex; leaf cells with strong trigones and frequent intermediate thickenings; stem anatomy schizostipous, the ventral merophytes 2 cells wide. .. .. *Tuyamælla*

3. Lobuli *unidentate*, apical tooth usually *undefined*; the hyaline papilla *marginal* and *terminal*; lobuli narrow, linear to lanceolate-tubular; leaves narrowly obovate to ovate-lanceolate; cells leptodermous with trogones; underleaves lobed near to base, lobes erect to suberect, lanceolate to linear, pointed; rhizoid-initial discs prominent; female bracts elongate-lingulate to linear obovoid; perianths not compressed; stem schizostipous with 7 rows of cortical cells, the ventral merophytes 2 cells wide; discoid gemmæ developed on leaf lobes .. .. .. *Siphonolejeunea*

It was further found that *Pycnolejeunea* s. str. was still a "cumbersome" genus due to the polymorphic nature of its constituents; the polymorphism being depicted by stem anatomy and lobule structure: the stem anatomy ranging from holostipous to typically schizostipous. However, in all cases the cortical cells are more or less thick-walled but the ventral merophytes range from 4–2 cells wide. Accordingly Kachroo and Schuster (*loc. cit.*) divided this genus into two subgenera: *Pycnolejeunea* and *Perilejeunea*. The latter includes a single species: *P. grandistipula* Gottsche *et* Steph. and may deserve the rank of a genus. But the former subgenus remains still a polymorphic entity. But it was thought unwise to separate these extreme variables further into two or more subgenera and the species studied by them were consequently separated into a few sections. The lobules were found to be of 3 distinct types as enumerated below:—

a *P. schwaneckei* type: lobule narrow, lingulate to oblong with sinus long and oblique gradually running into lobemargin; lobule inflated chiefly along keel.

b *P. papulosa* type: lobule inflated hemispherically into basal $\frac{2}{3}$, less than $\frac{1}{3}$ the length of lobe.

c *P. decurviloba* type: lobule size not larger than in (*b*), only basal $\frac{1}{4}$ to $\frac{1}{3}$ sharply inflated, the remainder being declivous against the lobe and appressed against it, lobuli recurved and open obliquely to the back than towards the lobe apices.

On the basis of the above features and variations observed in the stem anatomy (of the species studied) the genus was further subdivided into eight sections, represented by species: *P. decurviloba*, *P. bidentula*, *P. sphæroides*, *P. spruceana*, *P. multiflora*, *P. novoguineensis*, *P. utriculata* and *P. macroloba*.

Pycnolejeunea sensu Stephani *et* Hoffmann was found to include a majority of species which could be immediately referred to *Cheilolejeunea* emend. Schuster. However, on closer scrutiny it appeared that they differ from *Cheilolejeunea* (incl. *Euosmolejeunea*) in 3 distinct features: (*a*) lobule typically elongate, 2·4–4× as long as wide, usually 0·5–0·8 the length of lobe; (*b*) an elongated often acuminate or falcately curved apical tooth, 2–7 cells long (in a uniseriate row) with the base frequently 2 cells wide, distal hyaline papilla thus inserted 2–7 cells from the apex of lobule; and (*c*) dorsal lobes, in species with narrow lobuli and pleuricullar apical tooth, narrowly ovate and even somewhat oblong-lingulate. To accommodate these species within *Cheilolejeunea* they described a new subgenus, *Xenolejeunea*. Unfortunately this subgenus includes a group of diverse forms which fall under definite sections as given below:—

Group I. Lobular apical tooth 2-several cells long (and 1–2 cells broad at base), the hyaline papilla 2–6 (–7) cells from the apex of lobule; lobuli always narrow and elongate, 0·5–0·85 the length of lobe.

(*a*) lobes narrowly oblong to ovate-oblong to obovate-oblong.

Sectio Imbricatæ (Type: *C. imbricata*).—Stem with 18–24 rows of cortical cells that are thick-walled and slightly larger than medullary; ventral merophytes 4 cells broad; lobes widely spreading (75–85°); lobular apical tooth 2–3 cells long; keel long, nearly straight, at an angle of 70–85°.

Sectio Ceylanicæ (Type: *C. ceylanica*).—Stem with 7 (in case of *C. tosana* 10) rows of enlarged cortical cells, ventral merophytes 2-cells wide; lobular apical tooth 3–7 cells long; keel usually at an angle of 55–70° (in *C. longiloba* 75–85°), usually somewhat convex.

(*a*) Lobes broadly ovate, little or not longer than broad.

Sectio Incisæ (Type : *C. incisa*).—Apical tooth 2 cells long, straight; lobuli 0·6–0·65 the length of lobe, normal in size; *c.* 16 rows of cortical cells.

Sectio Setiferæ (Type *C. setifera*).—Apical tooth *c.* 5 cells long, uniseriate throughout, long and falcate; lobuli 0·8–0·85 the length of lobe, very large; stem with 7 rows of cortical cells.

Group II. Lobular apical tooth 1- (rarely 2) celled, short and blunt, lobuli 0·5–0·2 the length of lobe; lobe narrow, oblong-lingulate to oblong-rectangulate; stem with 7 rows of cortical cells.

Sectio Vittatæ (Type: *C. vittata*).—Lobuli larger, 0·5 the length of lobe; lobe with a basal area of strongly elongated, enlarged cells.

Sectio Discoidea (Type: *C. discoidea*).—Lobuli very small: 0·2–0·5 the length of lobe; lobe without vitta.

Species of *Pycnolejeunea s. lat.* with the hyaline papilla entally displaced have been segregated into three genera.

Hattori (1944) described *Nipponolejeunea*, based on *Pycnolejeunea pilifera* Steph. This genus is related to the primitive members of Holostipæ in similar stem anatomy, trigonous, compressed perianth and the seta of capsule with 16 peripheral cell rows.

Tuyamælla Hattori (1947) is based on *Pycnolejeunea molischii* Schiffner (1929), shares a number of features with Schizostipæ and Paradoxæ, and is probably related more to the latter.

Herzog (1948) described *Siphonolejeunea*, based on *Pycnolejeunea schiffneri* Steph. *in lit.* This genus is closely related to *Tuyamælla* and has reduced type of lobular structure.

For sake of completeness a list of species recognized by Kachroo and Schuster (1958) under *Pycnolejeunea* s. str., *Nipponolejeunea*, *Tuyamælla*, *Siphonolejeunea* and *Cheilolejeunea* subg. *Xenolejeunea*, may be given below.

Pycnolejeunea.—*P. bidentula* Steph., *P. borneensis* Steph., *P. callosa* (Lbdg.) Steph., *P. decurvifolia* Steph., *P. decurviloba* St., *P. diussa* (St. in herb.) Kachroo *et* Schuster, *P. macroloba* (Mont.) Spr. *ex* Schiffn., *P. malaccensis* Steph., *P. multiflora* Steph., *P. novoguinensis* Steph., *P. papulosa* Steph., *P. schwaneckei* (St.) Schiffn., *P. sphæroides* (Sde. Lac.) Steph., *P. spruceana* Schiffn., *P. renistipula* (St. in herb.) Schuster *et* Kachroo, *P. utriculata* Steph., and *P. ventricosa* Schiffn.

Nipponolejeunea.—*N. pilifera* (St.) Hattori (= *P. pilifera* St.), *N. subalipna* (Horik.) Hattori (= *P. subalpina* Horikawa).

Tuyamælla.—*T. molischii* Hattori (= *P. molischii* Schiffn). *T. angulistipa* (St.) Schuster *et* Kachroo (= *P. angulistipa* Steph). *T. appendiculata* (Hertz.) Schuster *et* Kachroo (= *P. appendiculata* Herzog.).

Siphonolejeunea.—*S. schiffneri* (St.) Herzog (= *P. schiffneri* Steph. in lit.), *S. nudicalycina* Herzog.

Cheilolejeunea subg. *Xenolejeunea.*—*C. ceylanica* (G.) Schuster *et* Kachroo (= *L. ceylanica* G.), *C. cookiensis* (St.) Schuster *et* Kachroo (= *P. cookiensis* Steph.), *C. discoidea* (L. *et* L.) Kachroo *et* Schuster (= *P. discoidea* L. *et*. L.), *C. falsinervis* (St.) Kachroo *et* Schuster (= *P falsinervis* Steph.), *C. gigantea* (St.) Schuster *et* Kachroo (= *P. gigantea* Steph.), *C. imbricata* (Nees) Schuster *et* Kachroo (= *L. imbricata* Nees), *C. incisa* (G.) Schuster *et* Kachroo (= *P. incisa* Gottsche), *C. longidens* (St.) Schuster *et* Kachroo (= *P. longidens* Steph.), *C. longiloba* (St.) Kachroo *et* Schuster (= *P. longiloba* Steph.), *C. meyeniana* (G. L. *et* N.) Schuster *et* Kachroo (=L.

meyeniana G. L. *et* N.), *C. micholitzii* (St.) Kachroo *et* Schuster (= *P. micholitzii* Steph.), *C. setifera* (St.) Schuster *et* Kachroo (= *P. setifera* Steph.), *C. tosana* (St.) Kachroo *et* Schuster (= *tosana* Steph.), *C. trapezia* (Nees) Kachroo *et* Schuster (= *L. trapezia* Nees), *C. verdoornii* (Hoffm.) Kachroo *et* Schuster (= *P. verdoornii* Hoffm.), *C. vittata* (St.) Schuster *et* Kachroo (= *P. vittata* Steph.). (The above list includes only the species studied by the authors.)

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References

Evans, A. W. 1906. Hepaticæ of Puerto Rico. VI. *Bull. Torrey bot. Cl.* **33**: 1–25.

Hattori, S. 1944. Contributio ad floram Hepaticarum Austro-Kiushiuensen. *Bull. Tokyo Sci. Mus.* **11**: 124–26; *See* also 1947. *Biosphera.* **1** (3–7); 1947. *Nat. Sci. Mus. Tokyo.* **15**: 76.

Herzog, T. 1948. Studien über Kritische und neue Lejeuneaceæ der Indomalaya. *Svensk. bot. Tidskr.* **42**: 230–41.

Hoffmann, G. 1935. Monographisch studien über die indomalayischen Arten von *Pycnolejeunea. Ann. Bryol.* **8**: 87–106.

Kachroo, P. and Schuster, R. M. 1958. The genus *Pycnolejeunea* and its affinities with *Cheilolejeunea*, *Euosmolejeunea*, *Nipponolejeunea*, *Tuyamælla* and *Siphoneolejeunea. Proc. Linn. Soc. Lond.* (in Press).

Schiffner, V. 1893. Hepaticæ in Engler-Prantl *Nat. Pfl.-Fam.* **1**: 3–141.

————. 1897. Revisio der Gattungen *Omphalanthus* und *Lejeunea* im herbarium des Berliner Museums. *Bot. Jb.* **23**: 578–600.

————. 1929. Über epiphylle lebermosse aus Japan nebs einigen beobachtungen über rhizoiden, alateren und brutkorper. *Ann. Bryol.* **2**: 87–106.

Schuster, R. M. 1955. North American Lejeuneaceæ. I. *J. Elisha Mitchell sci. Soc.* **71**: 106–26.

Spruce, R. 1884–85. Hepaticæ Amazonæ et Andinæ. *Trans. bot. Soc. Edinb.* **15**: 63–308.

Stephani, F. 1914. *Spec. Hepat.* **5**: 597–637.

LEAF ANALYSIS AS A MEANS OF CROP NUTRITION STUDIES

I. Effect of Phosphate Supply on the Growth, Yield and Composition of *Hordeum vulgare* L.

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Introduction

Studies in crop nutrition under field conditions can be best done by observing the absorption of nutrients by plants. Mostly investigations on the effect of phosphate added to the soil has been confined to soil analyses for the available and total phosphate and to growth and final yield. Practically no work has been done on Indian soils to study the effect of phosphate applied to the soil on the nutrient uptake by the plant as revealed by leaf analysis.

Some of the more important contributions concerning growth and yield as influenced by phosphate application are those of Crist and Weaver (1924), Harrison (1929), McClelland (1931), Hamner (1940), Sircar and Sen (1941), Greaves and Pittman (1946), Larson *et al.* (1952) and others who have reported favourable effect on all aspects of plant growth as well as on yield.

As regards the effect of phosphate application on plant composition, Brenchley (1929) reported that the amount of phosphate absorbed by the plants increased in direct proportion to the phosphate given to the soil. Krantz and Chandler (1951) working on corn plant reported that the phosphorus content of leaves was not appreciably affected at lower rates of phosphate application.

Lagatu and Maume (1930) have emphasized the use of leaf analysis as a diagnostic character for determining the cultural influence on development of plants. Special mention may be made of Thomas and his associates (1937, 1938, 1939, 1939 *a* and 1944) who studied foliar diagnosis and illustrated by means of leaf analysis the results of manurial experiments with different crop plants. Lundegårdh (1947) has also shown the advantages of leaf analysis over soil analysis. Fullmer (1952) advocated the use of leaf analysis technique in connection with fertilizer tests for determining more critical levels for nitrogen, phosphorus and potassium in case of sugar beet. Ulrich (1952) in his review has also emphasized the use of plant analysis as a physiological basis for assessing the nutritional requirements of plants. Alexander *et al.* (1954) found definite relationship between yield of sugar beet and leaf

analysis value. In the present investigations also nutrient concentration of the leaf has been taken as an index of their availability in the soil.

Material and Methods

Barley (*Hordeum vulgare* L. *Var.* C. 251) was grown in field and superphosphate was applied in furrows at the time of sowing. Superphosphate treatment was given at five different levels, *i.e.*, 20, 40, 60, 80 and 100 lb. of P_2O_5 per acre. Along with these a no treatment control was also run. The entire experiment was laid out statistically with four replicates. Five plants were selected at random from each plot and height, tiller and leaf number and leaf area were recorded at three stages synchronising approximately with the physiological stages, *viz.*, tillering, heading and milky grain. These stages were at 50, 70 and 90 days respectively from the date of sowing. Number and weight of ears per plant, length, spikelet number and number of grains per ear and also absolute weight of grains were recorded at the time of harvest. Yield of grain and straw was also recorded.

Fully developed, healthy and green leaves of approximately the same age and expansion were collected at each sampling date, washed free of adhesive particles and dried in an oven at 80° C., powdered and stored for the determination of nitrogen, phosphorus and potassium. Nitrogen was estimated by the Gunning method (A.O.A.C., 1945); phosphorus by the colorimetric micro method (A.O.A.C., 1945) and potassium by the cobaltinitrite method (Piper, 1944). Data were statistically analysed. Analysis of variance was done and 'F' test was employed to evaluate the significance in each case.

Experimental Results

Linear growth of the plant was significantly affected. Maximum height was recorded in 80 P* at all the stages (Table I). At the heading stage all the treatments showed a significant rise over control except 60 P. Maximum tillering was recorded in 20 P at the vegetative stage (Table I). Further additions led to a gradual fall in tiller production. A significant increase in leaf number was recorded in 20 P over that of control (Table I). At the vegetative stage treatments above 20 P showed a decrease in leaf number with increase in dosage up to 100 P. At the heading and milky grain stage control had lowest number of leaves and 40 P highest. Leaf area was maximum in 20 P at the vegetative stage and in 40 P at the heading stage (Table I). Higher doses brought about a decrease in leaf area. At the milky grain stage a rise from control up to 60 P was observed.

At the vegetative stage the effect of phosphate on leaf dry matter accumulation was small though there was a gradual rise from control up to 80 P treatment (Table II). At the heading stage there was a rise from control up to 40 P but higher doses up to 80 P brought about a

* 20 P, 40 P, 60 P, 80 P and 100 P stand for 20, 40, 60, 80 and 100 lb. of P_2O_5 per acre respectively.

TABLE I

The Effect of Phosphorus Dressings on the Growth Characters of Barley Plant at Different Physiological Stagesin its Life-Cycle

Growth stages	P_2O_5 lb./acre						S.E.	C.D. 5%	C.D. 1%
	0	20	40	60	80	100			
				Vertical growth (height in cm.)					
Vegetative ..	42·69	48·00	46·04	42·67	48·85	48·25	1·085	3·269	4·521
Heading ..	61·52	71·63	68·82	66·00	80·01	77·25	1·537	4·631	6·405
Milky grain ..	92·72	97·78	88·40	92·47	103·40	97·35	2·638	7·958	10·992
				Tiller number (per plant)					
Vegetative ..	3·15	4·60	4·30	4·15	4·00	3·80	0·146	0·439	0·608
Heading ..	3·75	5·75	5·95	4·90	4·05	4·60	0·190	0·572	0·791
Milky grain ..	2·85	4·75	5·20	4·65	4·40	4·05	0·126	0·379	0·525
				Leaf number (per plant)					
Vegetative ..	13·05	22·40	19·30	18·15	16·35	15·45	0·828	2·495	3·450
Heading ..	17·95	23·30	26·10	20·80	17·70	20·05	1·122	3·388	4·671
Milky grain ..	10·05	18·40	22·05	20·05	16·95	15·00	1·229	3·703	5·121
				Foliage expansion (Area, sq. cm./plant)					
Vegetative ..	210·62	389·15	357·51	343·60	358·83	307·60	26·432	79·645	110·143
Heading ..	296·33	473·00	549·02	446·47	452·02	439·72	19·206	57·872	80·032
Milky grain ..	250·08	457·84	516·31	541·33	509·56	470·74	26·437	79·660	110·164

TABLE II

The Effect of Phosphorus Dressings on the Dry Matter Accumulation of Barley Plant at Different Physiological Stages in its Life-Cycle

Growth stages	P_2O_5 lb./acre						S. E.	C.D. 5%	C.D. 1%
	0	20	40	60	80	100			
	Leaf dry matter (weight, g./plant)								
Vegetative ..	0·601	0·707	0·812	0·832	0·877	0·802	0·042	0·127	0·175
Heading ..	0·670	1·297	1·302	1·212	1·015	1·202	0·042	0·127	0·175
Milky grain ..	0·682	1·547	1·575	1·595	2·032	1·610	0·148	0·446	0·617
	Stem dry matter (weight, g./plant)								
Vegetative ..	0·485	0·660	0·677	0·612	0·682	0·640	0·045	0·135	0·187
Heading ..	1·000	2·105	1·782	1·432	1·342	1·485	0·032	0·096	0·133
Milky grain ..	2·154	5·365	3·977	4·592	5·095	3·597	0·208	0·627	0·867

reduction in leaf dry weight. At the milky grain stage a continuous rise was recorded from control up to 80 P. Stem dry matter accumulation did not show significant treatment effect at the vegetative stage (Table II). At the heading stage a marked rise was seen in 20 P over that of control. With further additions of phosphate there was a decrease in stem dry matter up to 80 P. Maximum leaf weight was again recorded in 20 P at the milky grain stage and minimum in control. With increase in age of the plants there was a rise in both the leaf and stem dry matter accumulation in all the treatments.

The number of ears per plant at the time of harvest was maximum in 60 P and was significantly higher than all other treatments (Table III). The weight of ears per plant showed significant increase in 60 P and 80 P as compared to all other treatments. Length of ears was significantly affected by phosphate treatments. There was a gradual rise in ear length up to 80 P treatment with an insignificant decrease in 60 P and 100 P treatments. Control had the least number of spikelets per ear and 80 P had the maximum number of spikelets. Phosphate treatments had led to a significantly higher number of grains per ear in all the treatments over control. 80 P treatment proved to be the best. Absolute weight of 1000 grains had also been found to be significantly affected by phosphate treatments. 20 P had significantly highest grain weight as compared to all other treatments except 60 P.

Grain yield was significantly affected by phosphate treatments (Table IV). Maximum yield was recorded in 80 P treatment while no treatment gave the minimum grain yield. There was a significant rise in grain yield in 20 P as compared to control. There was, however, again a significant rise in 80 P but 100 P showed slight depression in yield. The effect of phosphate treatments on straw production was also significant. Here a rise was recorded from control up to 80 P which gave maximum yield. 100 P had a depressing effect on straw production which was significant. The straw/grain ratio was maximum in control and minimum in 100 P treatment. A gradual fall from control up to 100 P was noticed with the exception of 60 P which gave higher ratio.

The uptake of nitrogen as revealed by leaf analysis was significantly affected by the level of phosphate supply at the vegetative stage. At this stage a rise in leaf nitrogen from control up to 40 P treatment was noticed (Table V). At the heading stage the effect of phosphate treatment on nitrogen uptake proved to be insignificant. There was a fall in 20 P and then a rise in 40 P treatment. Further higher doses led to a gradual fall in leaf nitrogen values. At the milky grain stage, a significant fall from control up to 60 P was found. Higher doses again led to an increase in nitrogen uptake.

There was a gradual rise in the leaf P_2O_5 values with increase in doses of phosphate application up to 100 P at the vegetative stage (Table V). At the heading stage a slight rise in 20 P and then a fall in 40 P treatment was recorded. Further addition of phosphate increased the leaf P_2O_5 percentage but 100 P treatment again showed depression. At

TABLE III

The Effect of Phosphorus Dressings on the Ear Characters of Barley

Characters	P_2O_5 lb./acre						S.E.	C.D. 5%	C.D. 1%
	0	20	40	60	80	100			
Ears/plant (No.) ..	2·55	4·15	4·00	4·85	4·45	3·65	0·113	0·341	0·461
Ear/weight (g./plant) ..	3·29	6·78	5·74	7·41	8·35	5·73	0·307	0·925	1·279
Ear length (cm.) ..	15·93	16·80	16·92	16·59	17·54	17·04	0·293	0·883	1·221
Spikelet No. (per ear) ..	10·91	12·48	12·82	12·57	14·62	12·87	0·319	0·961	1·329
Grain No./ear ..	26·25	32·12	30·13	30·62	37·02	35·08	1·159	3·492	4·830
Grain/wt. (absolute, g.) ..	41·32	43·11	41 56	42·32	41·26	39·99	0·418	1·450	2·000

TABLE IV

Grain and Straw Yield of Barley as Affected by Phosphorus Dressings (lb./acre)

Yield	P_2O_5 lb./acre						S.E.	C.D. 5%	C.D. 1%
	0	20	40	60	80	100			
Grain ..	526·55	791·77	838·23	921·99	1391·93	1274·80	62·38	187·96	259·94
Straw ..	1738·06	1850·33	1951·32	2250·11	2475·17	2145·09	64·34	193·87	268·11
$\frac{\text{Straw}}{\text{Grain}}$ ..	3·30	2·34	2·21	2·44	1·78	1·68	..	..	..

TABLE V

Leaf Composition at Different Physiological Stages of Growth of the Barley Plant

(oven-dry basis)

G. per 100 g.

Growth stages	P_2O_5 lb./acre						S.E.	C.D. 5%	C.D. 1%
	0	20	40	60	80	100			
				Nitrogen (N)					
Vegetative ..	2·950	3·100	3·450	3·250	3·350	3·150	0·132	0·399	0·552
Heading ..	3·625	3·325	3·700	3·600	3·500	3·300	0·160	0·482	0·662
Milky grain ..	3·220	3·000	2·800	2·400	2·800	3·000	0·113	0·342	0·484
				Phosphorus (P_2O_5)					
Vegetative ..	0·3968	0·4751	0·5731	0·5902	0·6278	0·6294	0·0272	0·0819	0·1133
Heading ..	0·6323	0·6675	0·6465	0·6646	0·6747	0·6049	0·0203	0·0612	0·0846
Milky grain ..	0·5473	0·5564	0·6915	0·7493	0·7050	0·6943	0·0236	0·0711	0·0988
				Potash (K_2O)					
Vegetative ..	4·285	3·775	4·047	4·489	4·152	4·357	0·157	0·473	0·654
Heading ..	4·790	4·330	4·455	4·678	4·406	4·047	0·139	0·419	0·579
Milky grain ..	3·420	2·087	2·447	3·733	4·060	3·061	0·177	0·533	0·737

the milky grain stage there was a significant increase in leaf P_2O_5 in 40 P treatment. There was a further increase in 60 P and then a fall in 80 P and 100 P treatments. In general, there was an increased phosphorus uptake as indicated by leaf analysis values with increase in age of the plants and larger increase was seen with the first addition and at initial stages.

The uptake of potash at the vegetative stage showed a decrease in 20 P treatment as compared to control (Table V). With further additions of phosphate a rise was noticed up to 60 P treatment only. At the heading stage maximum leaf potash value was recorded in the control. There was a significant fall in 20 P treatment but higher treatments of 40 P, 60 P and 80 P did not show significant changes. At the milky grain stage a significant fall in 20 P treatment was noticed, but doses above this gradually increased the potash content of leaves which was maximum in 80 P and was significantly higher than all other treatments except 60 P. It was noticed that there was a fall in leaf potash values with increase in age of the plants, especially at the final stage.

Discussion

The phosphate treatments on barley plant grown on sandy loam soil indicated that low doses of P_2O_5 increased height, medium doses led to a depression but high dose again showed a rise (Fig. 1 D). Tiller number and leaf number showed highest values under lower treatments while with higher doses there was a gradual fall (Fig. 1 E and F). Raheja and Misra (1955) working on wheat also found increase in the vertical growth of the plant following phosphate application to the soil, and Rege and Sannabhadti (1943) reported increased tillering with phosphate manuring. Sircar and Sen (1941) had also reported reduction in height and tiller production with phosphorus deficiency. Leaf area also showed a very marked rise in lower doses as compared to control but higher doses did not bring in appreciable rise, and in some treatments a fall was noticed (Text-Fig. 1 G). Thus, it seems that only low doses, *i.e.*, 20 P and 40 P favoured leaf expansion because in these treatments more of nitrogen uptake was seen which had a favourable effect on leaf area (Text-Fig. 1 A and G). It is true that nitrogen controls foliage expansion yet superphosphate played an equally important role as was evidenced by these observations. With initiation of the reproductive stage and the setting of seeds, larger dose of phosphorus became necessary for larger leaf area. This behaviour was probably so because at the said stage there was heavier drain of superphosphate from the soil. Consequently, only larger dressings could keep up leaf area higher with increase in age. These observations also applied in principle to leaf number and tiller number.

Leaf and stem dry weight showed an increase in lower doses of P_2O_5, while medium doses did not lead to marked change but high doses brought an initial depression which later on disappeared and there was a rise in these treatments (Text-Fig. 1 H and I). This was associated

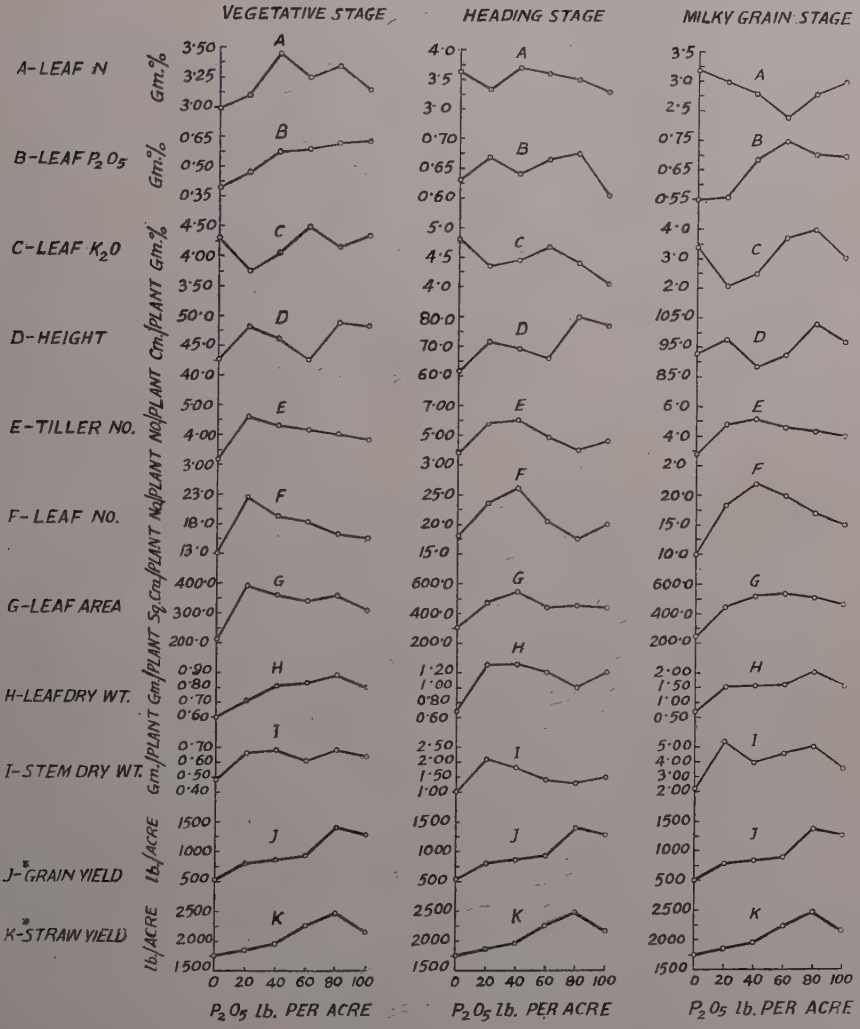
with low nitrogen, high phosphoric acid and moderate potash percentage in the leaf of these treatments. Similar effect on growth had been reported by Williams (1936), who also found an initial depression with highest phosphate supply.

Correlation studies between the various growth attributes at different physiological stages showed that height of the plants had a positive correlation with tiller number, leaf number and leaf dry weight up to 60 P treatment at the vegetative and heading stages but there was no such correlation beyond 20 P at the milky grain stage (Text-Fig. 1 D with E, F and H). There was a strong correlation between tiller number and leaf number at all the stages and under all the treatments (Text-Fig. 1 E and F). This similarity was associated with meristematic activity of the plants. The treatments which favoured tillering also favoured development of new leaves by the initiation of newer primordia. The tiller number was found to be closely correlated with stem dry matter at all the stages and under all the treatments and especially so at the vegetative and heading stages (Text-Fig. 1 E and I). A similar correlation was also recorded for leaf number and leaf dry weight (Text-Fig. 1 F and H). The leaf number and leaf area also had a similar trend throughout the plant's life-cycle with slight deviations at higher doses (Text-Fig. 1 F and G). The leaf dry weight and stem dry weight at the final stage of growth were also correlated (Text-Fig. 1 H and I). With increase in leaf weight there was an increase in stem weight also, while a decrease in leaf weight was associated with a decrease in stem weight in all the treatments. Thus, it may be said that the leaf production controls the dry matter accumulation in the stem as it is the centre of metabolic activities.

A marked similarity of the effect of phosphorus on the different ear characters of barley was visible. Number of ears, weight of ears, number of grains and absolute weight of grains showed that up to 40 P the trend was similar, *i.e.*, a significant rise at 20 P followed by a depression at 40 P (Table III). Larger doses formed another group which showed an identical behaviour with respect to all the above characters with a rise either at 60 P (number of ears) or at 80 P (weight of ears, length of ears, number of spikelets and number of grains) followed by a significant fall at 100 P. In general all the ear characters studied showed a decline at 100 P treatment. In some of these (number of ears and weight of ears per plant, number of grains per ear and absolute weight of 1000 grains), there were two treatments that gave significantly increased returns: showing two peaks, where as other characters (length of ears and number of spikelets per ear) showed only one peak rise. An increase in many of the ear characters with fertilization were also reported by Dunton (1949). Reitz and Myers (1944) also reported a slight increased test weight of grains with phosphate fertilization.

Grain yield increased with increase in phosphate treatments (Text-Fig. 1 J). A very sharp rise was recorded in 80 P treatment but 100 P had a lower grain yield. Increase in grain yield had also been reported

by several workers amongst whom McClelland (1931), Colwell (1947), Greaves and Pittman (1946) and Larson *et al.* (1952) may be mentioned. Straw yield also increased with phosphate treatments (Text-Fig. 1 K). Similar increase in straw yield was also reported by Reitz and Myers



TEXT-FIG. 1. Effect of phosphate application on growth, leaf composition at different physiological stages and final yield of barley.

* For ready reference and easy comparison, the curves for final grain and straw yield have been given under all the stages.

(1944). Straw/grain ratio showed a gradual fall from control up to 100 P treatment with the exception of 60 P which recorded a high ratio indicating comparatively larger straw production (Table IV).

From the results it was seen that at the vegetative stage there was a gradual rise from control up to 40 P treatment in nitrogen uptake (Text-Fig. 1 A). This was due to the favourable effect of phosphates on the nitrogen uptake as has also been reported by Rege and Sannabhadti (1943) for sugarcane. Similarly, Cibes *et al.* (1947) had also reported that P was required for the normal absorption and possibly the utilization of nitrogen by the plants. At higher phosphate treatments no rise was recorded because of the soil being poor in nitrogen which was evident from the fact that the soils had responded strongly to the application of nitrogen (Ranjan and Das, 1957). Contrary results had been reported for *Sorghum* by Samuels and Capo (1952). At the heading stage, the low value in 20 P treatment was due to an increased vegetative growth which had led to a dilution per unit gram of leaf material. The high values in 40 P and 60 P treatments as compared to control further supported the view that P_2O_5 favoured nitrogen uptake. Similar favourable effect of phosphate application on nitrogen had been reported by Eaton (1949). The fall in the lower treatments at the milky grain stage was due to translocation of nitrogen to the growing ears, which were developing fast. The low value in 60 P treatment indicated a more rapid transference of nitrogen to the grains which might have produced grains of better quality.

The uptake of phosphoric acid at the vegetative stage was very rapid in lower doses of 20 P and 40 P as shown by leaf analysis (Fig. 1 B). A corresponding increase in the growth of plants was seen. Higher doses of phosphate led to higher uptake of P_2O_5 but no increase in growth was recorded (Text-Fig. 1 B with D, E, F and G). Thus, it seems that luxury consumption of P_2O_5 had taken place at this stage in higher phosphate treatments. Chapman (1935) had also reported increased absorption of phosphate by oat plants at the vegetative stage due to application of phosphatic fertilizers. Comparatively low value at the heading stage in 20 P treatment was probably due to two reasons; firstly, due to an increased growth which led to a decrease in P_2O_5 per unit gram basis and secondly, due to the limited supply of phosphate to the plants. The rise in higher treatments was attributed to a limited growth of the plants and the presence of abundant phosphate in the soil. At the milky grain stage the significant rise from 20 P to 40 P and 60 P treatments indicated a luxury increase in these treatments. Lundegårdh (1932) had also reported that with high phosphoric acid manuring the phosphate content of the leaves can become very high without growth being appreciably affected. There was, indeed, a rise in the grain yield in these treatments (Text-Fig. 1 J). Thus, it seems that although the translocation of phosphoric acid to developing grains was going on, the uptake of phosphoric acid from the soil was also taking place at a fairly high rate. Therefore, it can be concluded that these doses were favourbale for yield. The deficiency of nitrogen was also an important factor in the increased uptake of P_2O_5 by the plants (Chapman, 1935) due to increased root development and restricted top development.

The uptake of potash in control plants was higher than 20 P and 40 P treatments (Text-Fig. 1 C). It was due to a very limited growth of control plants and also because the treated plants showed comparatively greater growth especially so in leaf number and leaf area (Text-Fig. 1 F and G). Thus, the uptake of potash in these treatments fell in arrear with growth of the plants and hence low values were seen. The high values in higher P_2O_5 treatments were due to a limited vegetative growth and it might have been due to the application of phosphate to the soil which led to increased uptake of K_2O as was suggested by Samuels and Capo (1952) for sugarcane. At the heading stage also the trend was almost the same as at the vegetative stage except that at the highest dose a fall in K_2O values was seen. At the milky grain stage, the higher values recorded in higher treatments of phosphate was either due to continued uptake of potash or because the translocation of K_2O to other parts was delayed. Rauterberg and Schulte (1942) had also reported more potash absorption at higher P_2O_5 levels than at lower levels. It seems that medium doses of phosphoric acid were most favourable for potash uptake as indicated by leaf analysis.

Leaf nitrogen and growth characters such as tiller number, leaf number and leaf area also exhibited similar trend at the vegetative stage which lends support to the view that leaf nitrogen controls growth characters to a large extent (Text-Fig. 1 A with E, F and G). There was an inverse relationship between leaf nitrogen and leaf potash which was quite evident at all the doses and stages especially so at the milky grain stage where, while one element increased the other decreased and *vice versa* (Text-Fig. 1 A and C). It has also been observed by Gildehaus (1931) for apples, Janssen and Bartholomew (1932) for cowpeas and sugar beet, Colby (1933) for French prune trees and Rippel *et al.* (1933) for potatoes that the amount of nitrogen was markedly higher in those plants that had been grown in a potassium deficient medium than in those that had been grown in a sufficient supply of this element. Janssen *et al.* (1934) found evidence in tomato plants that deficiency of potassium caused an accumulation of amino forms of nitrogen.

Leaf phosphorus at the heading stage showed a correlation with straw yield (Text-Fig. 1 B and K). With increase in leaf P_2O_5 a corresponding increase in straw yield was noticed. This relationship was very well borne out at the milky grain stage. Das (1956) has also reported similar positive correlation under N-P-K combination treatments. As phosphorus plays a very important role in all the metabolic processes, a reduction in phosphorus leads to many of the physiological processes being hampered and consequently a fall in straw yield.

Thus, it seems that there exists a correlation between many of the growth characters and the internal makeup of the leaf at different physiological stages in the plant's life-cycle.

The effect of phosphate fertilizers on metabolism could be distinguished into two categories, characterized by the age of the plants. The plants exhibited to some extent a similar trend in many of the characters studied up to the heading stage but after this the trend followed

a slightly different course, indicating thereby, that there existed a stage somewhere between the heading and the milky grain stages when the effect of phosphorus on the metabolic activites of the plant took a different course (Text-Fig. 1). This effect is similar to the one already pointed out for nitrogen by Ranjan and Das (1957), although it is less marked here than in the nitrogen treatments.

Summary

A study on the effect of phosphate application to barley (*Hordeum vulgare* L. var. C. 251) grown on the sandy loam soil under field conditions was conducted. The entire experiment was laid out statistically and all the data were subjected to statistical analysis. Superphosphate was applied at five different levels, *viz.*, 20, 40, 60, 80 and 100 lb. of P_2O_5 per acre. Along with these a no treatment control was also run. Records of height, tiller number, leaf number, leaf area, leaf and stem dry weight were taken at the vegetative, heading and milky grain stages. At these three stages leaf analysis was done for nitrogen, phosphorus and potassium. The ear characters and yield of grain and straw were also recorded.

The response to phosphate application indicated that the soil under investigation was deficient in phosphorus. The effect of phosphate application on growth, nutrient uptake at different physiological stages and the final yield has been reported and subsequently discussed on the basis of leaf composition. Higher treatments of phosphate were comparatively more effective during the heading-milky grain period than the lower treatments. The best dosage for maximum yield of straw and grain was 80 lb. P_2O_5 per acre.

Many growth characters showed positive correlations amongst themselves as well as with the nutrient composition of the leaf. A significant positive correlation was observed between leaf phosphorus and straw yield. The effect of phosphate application could be distinguished into two different categories, characterized by the age of the plants.

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References

Alexander, J. T., Schmer, C. C., Orleans, L. P. and Cotton, R. H. 1954. The effect of fertilizer application on leaf analysis and yield of sugar beets. *Proc. Amer. Soc. Sug. Beet Tech.* **8**: 370–79.

A.O.A.C. 1945. *Methods of Analysis of the Association of Official Agricultural Chemists.* Published by—Association of Official Agricultural Chemists, Benjamin Franklin Station, Washington D.C.

Brenchley, W. E. 1929. The phosphate requirement of barley at different periods of growth. *Ann. Bot. Lond.* **43**: 89–110.

CHAPMAN, H. D. 1935. Inorganic phosphate in green plant tissue as a measure of phosphate availability. *Soil. Sci.* **39**: 111–22.

CIBES, H. R., CHILDERS, N. F. AND LOUSTALOT, A. J. 1947. Influence of mineral deficiencies on growth and composition of vanilla vines. *Plant Physiol.* **22**: 291–99.

COLBY, H. L. 1933. Effect of starvation on distribution of mineral nutrients in French prune trees grown in solution cultures. *Ibid.* **8**: 357–94.

COLWELL, W. E. 1947. Studies on the effect of nitrogen, phosphorus and potash on the yield of corn and wheat in Mexico. *Proc. Soil. Sci. Soc. Amer.* **11**: 332–40.

CRIST, J. W. AND WEAVER, J. E. 1924. Absorption of nutrients from subsoil in relation to crop yield. *Bot. Gaz.* **77**: 121–48.

DAS, N. 1956. Role of phosphate in plants. *Proc. nat. Acad. Sci. India.* A, **25**: 476–78.

DUNTON, H. L. 1949. The effect of varying the treatments of nitrogen, phosphorus and potassium alone and in combination on certain characteristics of dwarf grain sorghum. *Dissertation, Univ. Michigan.* 1–72.

EATON, S. V. 1949. Effect of phosphorus deficiency on growth and metabolism of sunflower. *Bot. Gaz.* **110**: 449–64.

FULLMER, F. S. 1952. Sugar beet leaf analysis survey in five Eastern States. *Proc. Amer. Soc. Sug. Beet Tech.* **9**: 166–71.

GILDEHAUS, E. J. 1931. The relation of nitrogen to potassium in the nutrition of fruit trees. *Bot. Gaz.* **92**: 384–95.

GREAVES, J. E. AND PITTMAN, D. W. 1946. Influence of fertilizers on the yield and composition of certain crops and on the soil. *Soil Sci.* **61**: 239–46.

HAMNER, C. L. 1940. Growth of biloxi soybeans to variations in relative concentrations of phosphate and nitrate in the nutrient solutions. *Bot. Gaz.* **101**: 637–48.

HARRISON. 1929. In *Proceedings of the Board of Agriculture in India*, App. I.

JANSSEN, G. AND BARTHOLOMEW, R. P. 1932. The effect of potassium on the production of proteins, sugar and starch in cowpea and in sugar beet plants and the relation of potassium to plant growth. *J. Amer. Soc. Agron.* **24**: 667–79.

——, —— AND WATTS, V. M. 1934. Some effects of nitrogen, phosphorus and potassium on composition and growth of tomato plants. *Bull. Ark. agric. Exp. Sta.* **310**.

KRANTZ, B. A. AND CHANDLER, W. V. 1951. Lodging, leaf composition, and yield of corn as influenced by heavy application of nitrogen and potash. *J. Amer. Soc. Agron.* **43**: 547–52.

LAGATU, H. AND MAUME, L. 1930. Le diagnostic foliaire de la pomme de terre. *Ann. Éc. Agric. Montpellier.* **20**: 219.

LARSON, W. E., NELSON, L. B. AND HUNTER, A. S. 1952. The effect of phosphate fertilization upon the yield and composition of oats and alfalfa grown on phosphate deficient Iowa soils. *J. Amer. Soc. Agron.* **44**: 357–61.

LUNDEGÅRDH, H. 1932. *Nahrstoffaufnahme der Pflanze*, Jena.

————. 1947. Mineral nutrition of plants. *Annu. Rev. Biochem.* **16**: 503–38.

MCCLELLAND, C. K. 1931. Effects of various plant foods on growth activities and development of oats. *J. Amer. Soc. Agron.* **23**: 304–11.

PIPER, C. S. 1944. *Soil and plant analysis.* Published by The Univ. of Adelaide, Adelaide.

RAHEJA, P. C. AND MISRA, M. D. 1955. Development studies in crop plants. I. Influence of nitrogen, phosphate, potash and calcium alone and in combination on wheat. *Indian J. agric. Sci.* **25**: 87–104.

RANJAN, S. AND DAS, N. 1957. Effect of nitrogen supply on nutrient uptake as revealed by leaf analysis and on the growth and yield of *Hordeum vulgare* L. *Proc. nat. Acad. Sci. India.* **B, 27**: 227–34.

RAUTERBERG, E. AND SCHULTE, E. 1942. Nutrient absorption and plant growth of plants supplied with different concentrations of potassium at two levels of phosphoric acid. *Ernahr. Pflanze.* **38**: 25–28; 37–39.

REGE, R. D. AND SANNABHADTI, S. K. 1943. Problems of sugarcane physiology in the Deccan Canal tract. IV. Mineral nutrition: (A) Phosphates. *Indian J. agric. Sci.*, **13**: 87–111.

REITZ, L. P. AND MYERS, H. E. 1944. Response of wheat varieties to application of superphosphate fertilizer. *J. Amer. Soc. Agron.* **36**: 928–36.

RIPPEL, A., BEHR, G. AND MYER, R. 1933. Zur Kenntnis der Wirkung des Kaluims auf hohere Pflanzen. *Z. PflErnähr. Düng.* **32**: 95–109.

SAMUELS, G. AND CAPO, B. G., 1952. Effect of a level of fertilizer element on the uptake and concentration of that element and other elements in a plant. *J. Amer. Soc. Agron.* **44**: 352–57.

SIRCAR, S. M. AND SEN, N. K. 1941. Studies in the physiology of rice. I. Effect of phosphorus deficiency on the growth and nitrogen metabolism in rice leaves. *Indian J. agric. Sci.* **11**: 193–204.

THOMAS, W. 1937. Foliar diagnosis: Principles and practice. *Plant Physiol.* **12**: 271–99.

——, AND MACK, W. B. 1938. Foliar diagnosis in relation to development and fertilizer treatment of the potato. *J. agric. Res.* **57**: 397–414.

——, and ——. 1939. The foliar diagnosis of *Zea mays* subjected to differential fertilizer treatment. *Ibid.* **58**: 477–91.

——, and ——. 1939 *a*. A foliar diagnosis study of the effect of three nitrogen carriers on the nutrition of zea mays. *Ibid.* **59**: 303–13.

——, ——, AND RAHN, E. M. 1944. Foliar diagnosis and plant nutrition in fertilizer placement experiments. *J. Amer. Soc. Agron.* **36**: 889–902.

ULRICH, A. 1952. Physiological bases for assessing the nutritional requirements of plants. *Annu. Rev. Pl. Physiol.* **3**: 207–28.

WILLIAMS, R. F. 1936. Physiological ontogeny in plants and its relation to nutrition. 2. The effect of phosphorus supply on growth of the plant and its parts. *Aust. J. exp. Biol. med. Sci.* **14**: 165–85.

STUDIES ON MELIACEÆ

I. Floral Morphology and Embryology of *Naregamia alata* W. & A.

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Introduction

Embryological studies on the predominantly tropical family Meliaceæ are far from adequate. Schnarf (1931), reviewing the literature, mentions the works of Karsten (1891) and Dersch (unpublished) on *Carapa guayanensis*. Capararo (1928) gave a small note on the oil-bearing idioblasts in the fruits of *Melia azedarach*. Paetow (1931) described the development of the gametophytes of *Dysoxylum ramiflorum* while Juliano (1934 *a*, *b*) studied the embryology of *Sandoricum kœtjape*. According to the latter author, the reduction divisions in the microspore mother cells are successive which is in contrast to the condition in other members of the family. Wiger's (1935) work on 40 species, representing 13 genera, has been adversely criticised by Mauritzon (1935). Chang and Wang (1956) studied the morphology of pollen grains in some members of the family. More recently Garudamma (1956, 1957) gave an account of gametogenesis and embryogeny in *Azadirachta indica*, and Narayana (1958) studied the gametogenesis in *Cipadessa baccifera*. The present paper deals with *Naregamia alata*, a short note on the early endosperm of which has already been published (Nair, 1956).

Material and Methods

Naregamia alata is a monotypic genus indigenous to the Western Ghats of India extending from Konkan southwards, and is often cultivated for medicinal purposes. It flowers almost throughout the year. The material for the present study was collected from plants growing under natural conditions in Changanacherry (Kerala State) from April to July, 1951. Additional collections were made in September, 1952 and 1953. Formalin-acetic-alcohol was used for fixation. To soften the seed coat, the seeds were treated with 10 per cent. hydrofluoric acid in 70 per cent. alcohol for three weeks. Sections were cut at 6 to 14 μ and stained with safranin and fast green. Advanced stages of embryos were dissected out from ripening seeds under a stereomicroscope.

Observations

Morphology of the flower.—*Naregamia alata* is a branching undershrub with trifoliate leaves and winged petioles. The axillary solitary flowers are pentamerous. The filaments are united to form an elongated tube. Its apical portion is inflated and is surmounted with triangular fringes (Text-Figs. 1, 1 *a*). Anthers are introrse and are inserted between the crenatures. The tricarpellary ovary is trilocular in the basal region and unilocular at the apex (Text-Figs. 10, 11). Each carpel bears two collateral ovules on an axile placenta. The cells of the septa and those at the base of the style proliferate giving rise to an obturator. It is a compact tissue of richly cytoplasmic elongated cells. The obturator grows downwards and covers the micropylar part of the ovule (Text-Figs. 12, 13). During post-fertilization development, the obturator is crushed by the enlarging seed.

Wiger (1935) makes a passing reference to the presence of an obturator in *Chickrassia* and adds that it is present in other members as well but does not specify the plants. An obturator is also present in *Cipadessa baccifera* (Narayana, 1958). Whether this is a common feature in the family remains to be investigated.

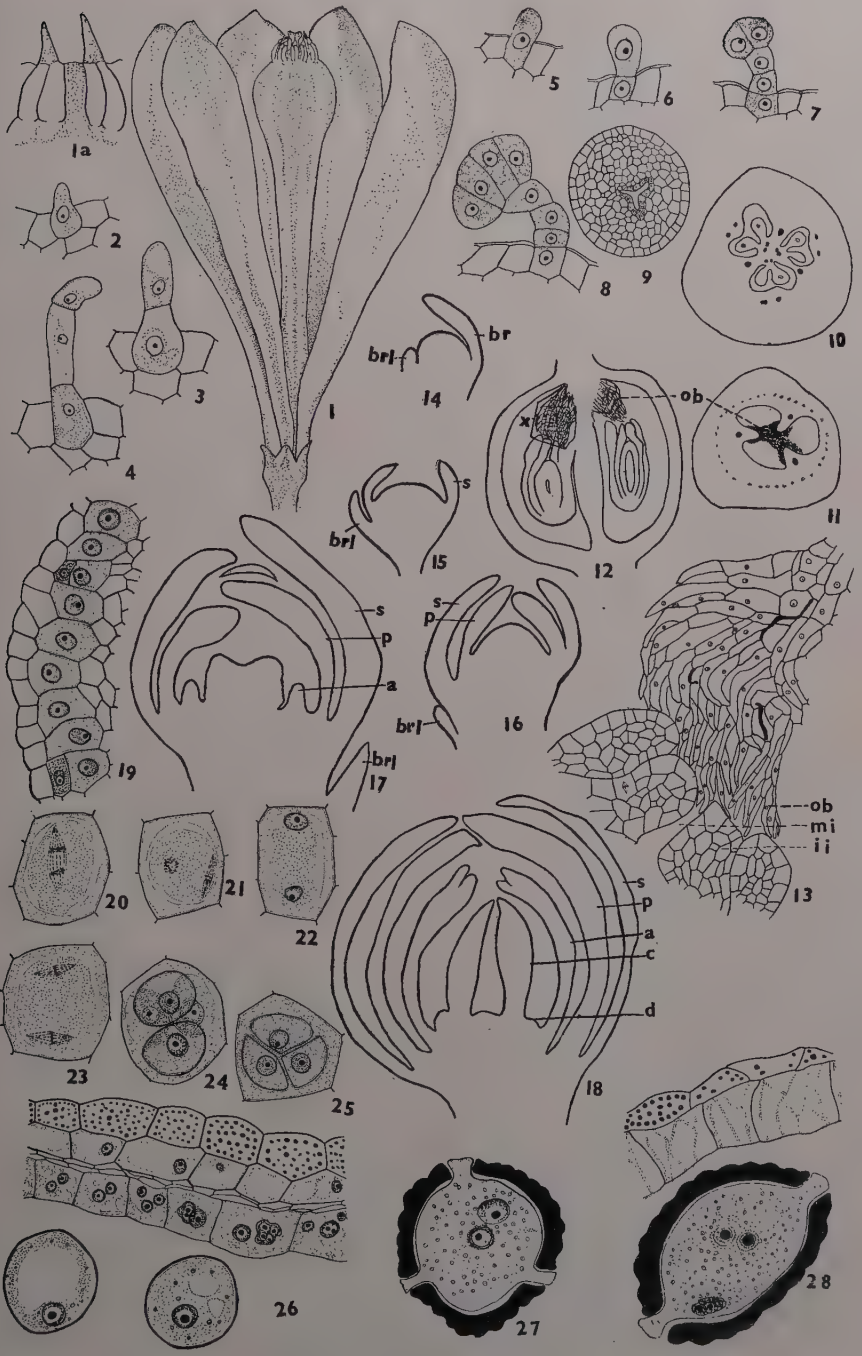
There is a long, slender, cylindrical style with a narrow triradiate stylar canal lined with the transmitting tissue (Text-Fig. 9). The trilobed stigma protrudes slightly beyond the staminal tube and is beset with glandular hairs (Text-Fig. 46).

Multicellular hairs, each comprising three to four cells, are present on the pedicel and calyx of the flower. The swollen basal cell is partly embedded in the epidermis. The development of the hair is represented in Text-Figs. 2–4. Stalked glands are also present on the sepals and ovary wall. The cell destined to become the gland elongates (Text-Fig. 5), and grows out into a papillate protrusion. It divides transversely (Text-Fig. 6) and the outer cell divides again. The terminal cell undergoes two or three vertical divisions producing a gland of four to six cells (Text-Figs. 7, 8). The subterminal cell divides once or twice forming the stalk.

During the development of the floral organs (Text-Figs. 14–18), the disc differentiates last of all as is also the case in *Sandoricum kætjape* (Juliano, 1934 *a*).

Microsporangium.—A row (sometimes two rows) of hypodermal archesporial cells differentiates in each lobe of the anther (Text-Fig. 19), and the primary parietal layer is cut off as usual. In *Carapa* (Schnarf, 1931) and *Azadirachta* (Garudamma, 1957) also there is a single row of microspore mother cells (*see also* Wiger, 1935). There are 4 rows of sporogenous tissue in *Dysoxylum ramiflorum* (Paetow, 1931) and three in *Sandoricum kætjape* (Juliano, 1934 *a*).

The primary parietal layer gives rise to the endothecium, two middle layers, and the tapetum (Text-Fig. 26). The endothecial cells acquire



TEXT-FIGS. 1–28

TEXT-FIGS. 1–28. Fig. 1. An open flower, ×2. Fig. 1 *a*. Portion of the tip of the staminal tube showing triangular fringes, ×16·5. Figs. 2–4. Development of multicellular hair, ×150. Figs. 5–8. Development of stalked gland, ×150. Fig. 9. T.s. of style, ×75. Figs. 10, 11. T.s. ovary showing trilocular and unilocular condition, ×10. Fig. 12. L.s. of ovary, ×10. Fig. 13. The same, portion marked X in Fig. 12 enlarged to show the details of obturator, ×150. Figs. 14–18. Organogeny, ×20. Fig. 19. Part of anther lobe in L.s. showing archesporium, ×417. Figs. 20–23. Meiotic divisions in microspore mother cells, ×417. Figs. 24, 25. Decussate and tetrahedral tetrads, ×417. Fig. 26. Anther wall at uninucleate stage of pollen grains, × 417. Fig. 27. Two-celled pollen grain, ×417. Fig. 28. Portion of mature anther just before dehiscence, ×417. (*a*, stamen; *br*, bract; *brl*, bracteole; *c*, carpel; *d*, disc; *ii*, inner integument; *mi*, micropyle; *ob*, obturator; *p*, petal; *s*, sepal.)

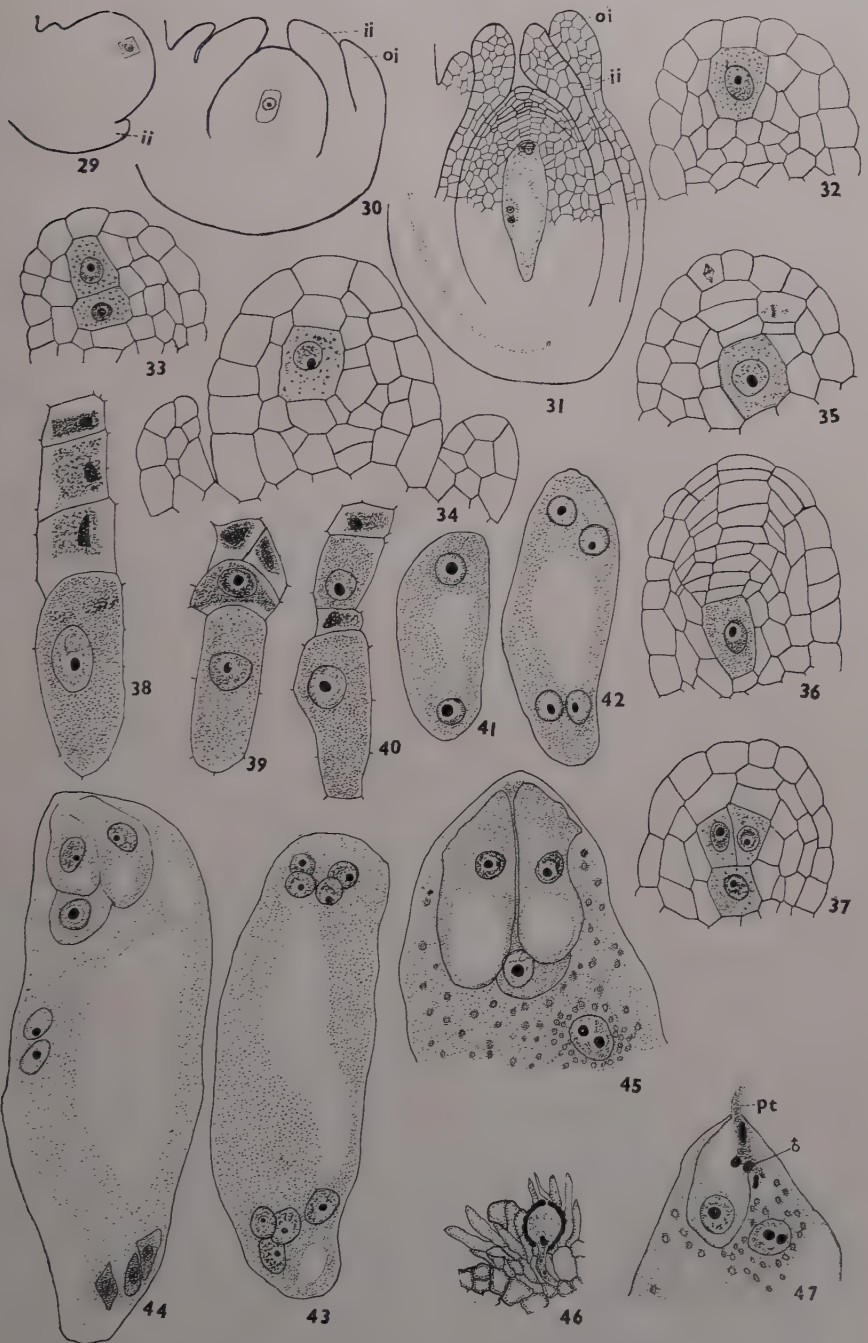
fibrous thickenings only after the pollen grains have reached the two-celled stage. As a result of mitotic divisions, the tapetal cells become two to four-nucleate. Some of these nuclei fuse, enlarge, contain two to four-nucleoli and have a lobed outline (Text-Fig. 26). In the mature anther, only the epidermis and the fibrous endothecium remain intact (Text-Fig. 28). The epidermis contain globules of deeply staining material. With the commencement of meiosis, the protoplasts of the microspore mother cells secrete a special mucilagenous wall which is very prominent at the corners (Text-Fig. 20). The reduction divisions are simultaneous and during meiosis II the spindles may be parallel or at right angles to each other giving rise to tetrahedral or decussate tetrads, the former condition being more common (Text-Figs. 20–25). During enlargement of microspores, the mucilagenous wall is consumed and the original mother wall breaks down.

Male gametophyte.—The young microspore is globular, and its wall soon differentiates into a thick exine and a thin intine. The former develops alternate ridges and furrows running from pole to pole.

The formation of a large vacuole displaces the nucleus to one side (Text-Fig. 26). The mature pollen grains contain abundant starch grains, show three germ pores with the intine slightly protruding through the germ pores, and are shed at the three-celled stage (Text-Figs. 27, 28) as is also the case in *Sandoricum kætjape* (Juliano, 1934 *a*). In *Dysoxylum ramiflorum*, Paetow (1931) reports that the shedding occurs at the one-celled stage. Wiger (1935) stated that two nucleate condition is characteristic of the family. These reports require confirmation.

Some times most of the pollen grains in a microsporangium degenerate. Rarely degeneration spreads to all the locules of an anther or even all the anthers in a flower. The degenerated grains are devoid of any contents and appear crumpled.

Megasporangium.—As in most other investigated species of the family the ovules are crassinucellate and bitegmic. It is straight at first but gradually curves upwards until it becomes anatropous (Text-Figs. 29–31). The inner integument arises first and forms the micropyle (Text-Fig. 31). This is also true for other members of the family except in *Dysoxylum ramiflorum* where the outer integument forms



TEXT-FIGS. 29–47

TEXT-FIGS. 29–47. Figs. 29–31. Development of ovule. Figs. 29, 30, ×300. Fig. 31, ×150. Figs. 32, 33. Archesporial cell, ×417. Figs. 34–37. Sporogenous cells, ×417. Figs. 38, 40. Linear tetrad of megaspores, ×417. Fig. 39. T-shaped tetrad, × 417. Figs. 41–44. Development of female gametophyte, ×417. Fig. 45. Micropylar region of mature embryo-sac, ×417. Fig. 46. Stigmatic lobe showing germinating pollen grain, ×183. Fig. 47. Upper part of embryo-sac just before fertilization, ×417. (*ii*, inner integument; *oi*, outer integument; *pt*, pollen tube.)

the micropyle (Paetow, 1931; *see also* Wiger, 1935). The inner integument is two to four-layered. Both are massive in the micropylar region. The outer epidermis of the outer integument and the inner epidermis of the inner integument contain tannin. The nucellus is massive and at the mature embryo-sac stage it consists of four to six layers of cells. The cells of the nucellar epidermis undergo periclinal divisions to form a cap of three to five layers of cells (Text-Figs. 31, 35, 36). A nucellar cap is also present in other members of the family (*see* Juliano, 1934; Wiger, 1935; Narayana, 1958). The funicular vascular strand terminates at the chalaza (Text-Fig. 31).

Megasporogenesis and female gametophyte.—Generally one or sometimes two to three hypodermal archesporial cells differentiate in the young nucellus (Text-Figs. 32, 33), and at this stage the microsporangium shows tetrads. Due to the formation of an extensive parietal tissue, the megaspore mother cell becomes deep seated (Text-Figs. 34–36).

The tetrads are linear or T-shaped (Text-Figs. 38–40), and the chalazal megaspore functions. The other three megaspores degenerate and usually the micropylar one collapses first (Text-Fig. 38). Sometimes the second or the third megaspore also remain healthy (Text-Figs. 39, 40) but twin embryo-sacs have never been observed.

The two-nucleate gametophyte shows a central vacuole (Text-Fig. 41). The four and eight-nucleate embryo-sacs undergo considerable enlargement (Text-Figs. 42, 43). As in other members of the family the development is of the Polygonum type (*see* Paetow, 1931; Juliano, 1934 *a*; Wiger, 1935; Nair, 1956; Garudamma, 1957; Narayana, 1958).

The mature embryo-sac is broader at the micropylar and narrower at the chalazal end (Text-Fig. 44). The synergids are hooked with the nucleus situated in the upper part while a vacuole occupies the basal portion (Text-Figs. 44, 45). The polar nuclei move to the centre and fuse close to the egg apparatus. The antipodal cells are ephemeral and degenerate even before the fusion of polar nuclei. The embryo-sac contains abundant starch grains particularly in the vicinity of the secondary nucleus. Wiger's (1935) statement that in most of the species studied by him "the synergid nuclei were placed in the lower part of the cell while the upper region was occupied by 'Fedenapparat' could not be confirmed by me."

Pollination and fertilization.—Since the flowers are markedly protandrous, cross-pollination seems to be the rule. Germinating pollen

grains have been observed on the stigma (Text-Fig. 46). The vegetative nucleus follows the male cells into the tube, but the nuclei become obscure while the pollen tubes traverse through the stylar canal. The obturator apparently serves to conduct and nourish the pollen tube.

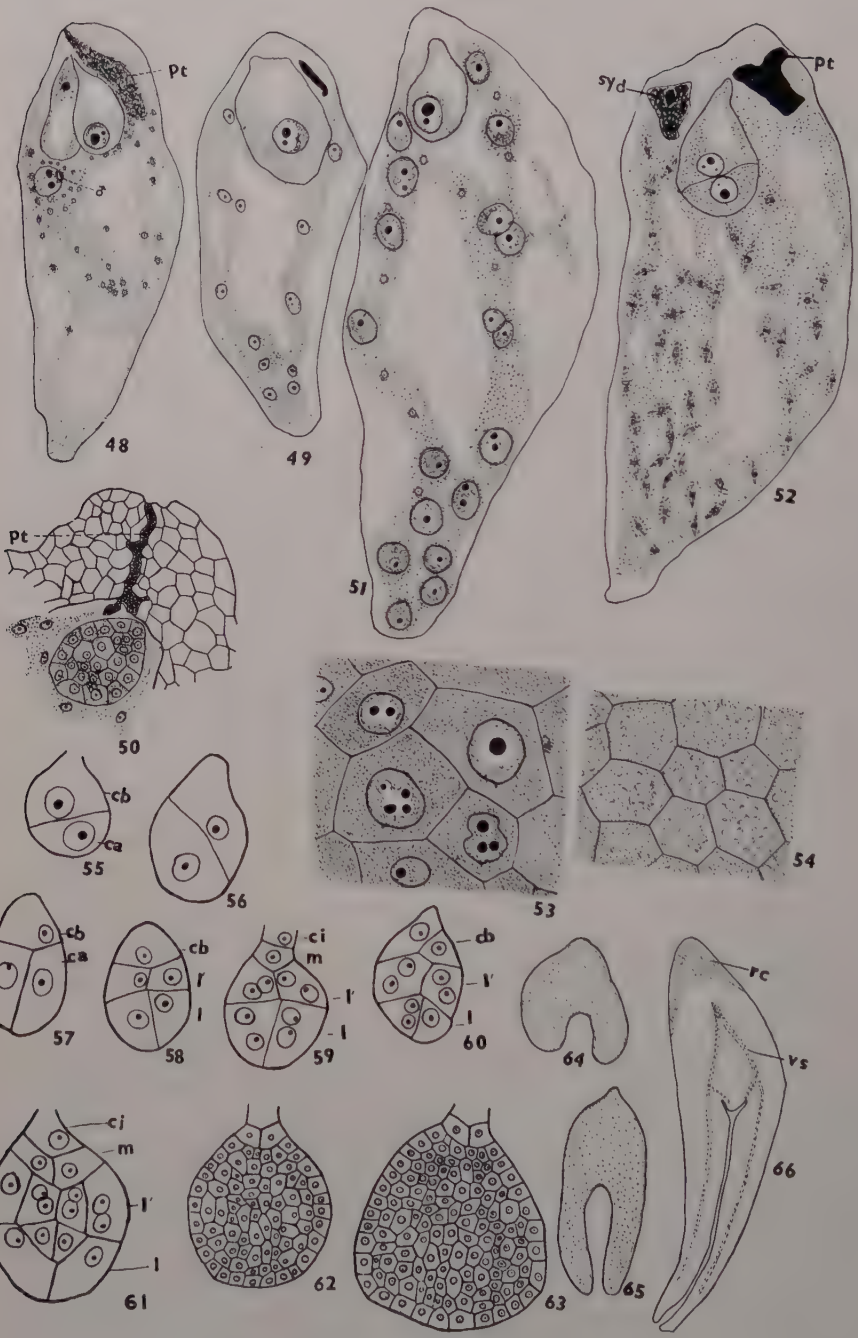
Fertilization is porogamous. The pollen tube enters the sac by destroying one of the synergids (Text-Fig. 48). Syngamy and triple fusion have been observed. In one case a male gamete was still attached to the secondary nucleus where as the egg was fertilized (Text-Fig. 48). The tip of the discharged pollen tube sometimes persists up to the globular stage of the proembryo and stains deeply (Text-Figs. 49, 50). Dark staining X-bodies have also been observed in the discharged end of the pollen tube (Text-Fig. 47).

Endosperm.—The division of the primary endosperm nucleus precedes that of the oospore (Text-Figs. 49, 51). Since the earlier divisions are not followed by wall formation, the development is free nuclear. There may be approximately 50 nuclei when the proembryo is two-celled (Text-Fig. 52). Free nuclear divisions continue until centripetal wall formation is initiated from the micropylar end at the heart-shaped stage of the proembryo. Some nuclei aggregate at the chalazal end of the embryo-sac (Text-Figs. 49–52).

The basal endosperm cells are richly cytoplasmic and contain prominent nuclei some of which are multinucleolate (Text-Fig. 53). During the enlargement and maturation of the embryo, it consumes much of the adjacent endosperm. Text-Fig. 54 represents a portion of the endosperm tissue with the cells full of food reserve, chiefly oil.

Embryo.—The oospore enlarges and by a transverse division gives rise to a terminal cell *ca* and a basal cell *cb* (Text-Fig. 55). In one case, the wall was obliquely oriented (Text-Fig. 56). The division of the basal cell is delayed while the terminal cell *ca* divides by a vertical wall (Text-Fig. 57). Subsequent divisions lead to the formation of the quadrant and octant stages (Text-Figs. 58–60). The basal cell *cb* divides transversely forming the cells *m* and *ci* (Text-Fig. 59). Sometimes *cb* divides by an oblique vertical wall (Text-Fig. 60). The cell *m* undergoes a vertical division and its daughter cells remain undivided (Text-Figs. 61–63). The two tiers of the octant are designated as *l* and *l'*. Periclinal divisions in these tiers demarcate the dermatogen (Text-Fig. 61). The globular and heart-shaped embryos are formed in the usual way. Derivatives of the tier *l'* give rise to the hypocotyl and root initials, and those of *l* to the cotyledons and stem tip. The initials of the cotyledons differentiate from the peripheral region of the apical tiers and develop rapidly (Text-Figs. 64–66).

Since *cb* contributes to the suspensor and the embryo proper is derived from *ca*, the development conforms to the Crucifer type (*cf.* Maheshwari, 1950).



TEXT-FIGS. 48–66

TEXT-FIGS. 48–66. Fig. 48. Fertilized embryo-sac, ×417. Fig. 49. Zygote and free nuclear endosperm, ×300. Fig. 50. Micropylar portion of an young seed at globular stage of pro-embryo, ×300. Fig. 51. Embryo-sac undivided zygote and free nuclear endosperm, note chalazal aggregation of nuclei, ×417. Fig. 52. Same advanced stage, ×417. Fig. 53. Part of cellular endosperm at heart-shaped stage of the embryo, ×417. Fig. 54. Same from mature seed, ×417. Figs. 55–66. Stages in development of embryo. Figs. 64, 65 are from dissections. Figs. 55–62, ×417. Figs. 64–66, ×42. (*pt*, pollen tube; *rc*, root cap; *syd*, synergid; *vs*, vascular tissue.)

Testa.—Soon after fertilization the integuments undergo conspicuous changes. In the micropylar region the cells of the outer epidermis of the inner integument elongate radially (Text-Fig. 69), while in the lower portion they undergo tangential elongation and become very conspicuous in the seed (Text-Figs. 67, 68). The hypodermal cells divide so that the inner seed coat consists of five to six layers (Text-Fig. 68).

The outer integument remains two-layered except in the micropylar region where it is three to four layers thick. The cells of the outer epidermis elongate radially, become papillate, and the walls get thickened. There is a thick cuticle for the epidermis and this, in the region of the papillae, is drawn out into fine hair-like structures which cover the mature seed (Text-Fig. 68).

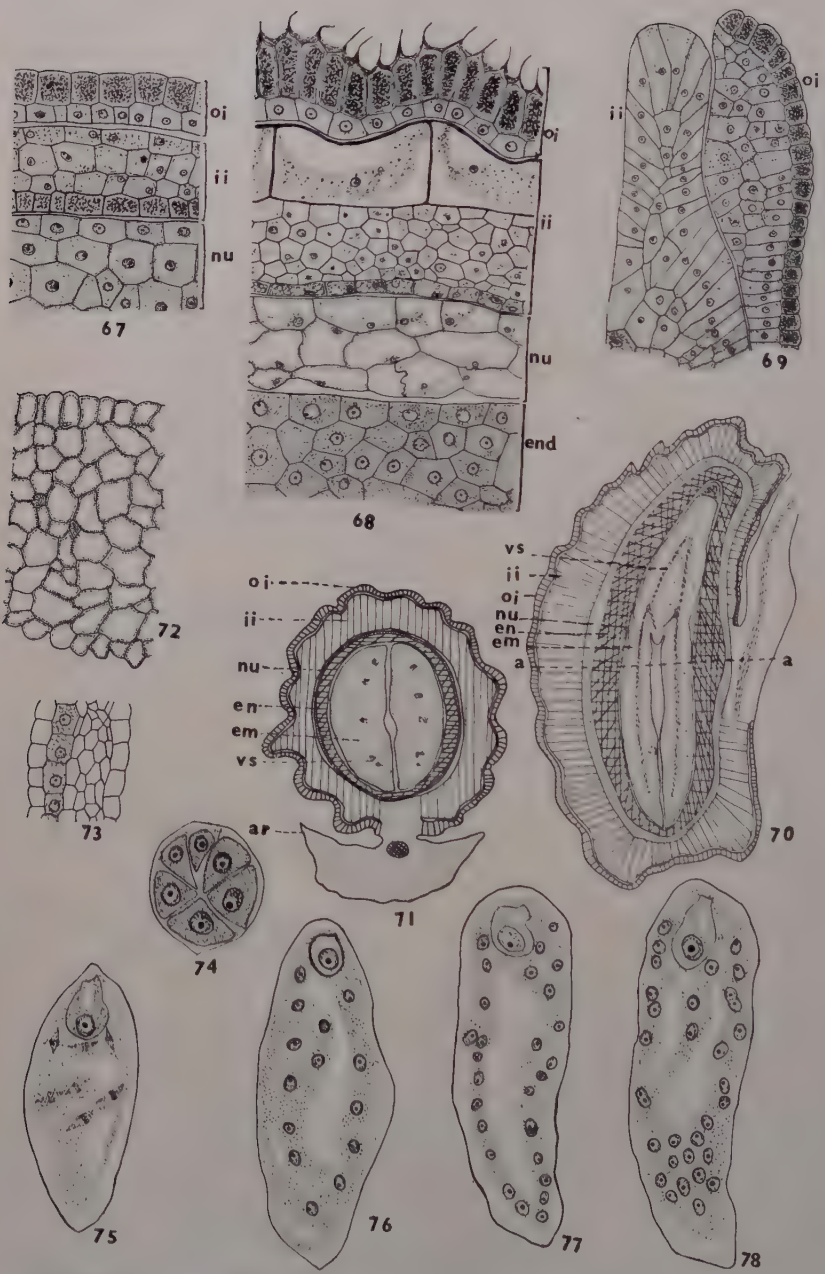
While the above changes are in progress, the peripheral cells of the funiculus divide actively to form a parenchymatous aril (Text-Fig. 72). This is white in colour and partly covers the ventral surface of the mature seed (Text-Fig. 71).

Pericarp.—At the time of fertilization the ovary wall is composed of eight to nine layers of cells. The cells of the hypodermal layer are large and glandular and in younger stages they contain dense cytoplasm and conspicuous nuclei. Soon after fertilization they become vacuolated (Text-Fig. 73) and get crushed during maturation of the capsule wall. The latter comprises six to seven layers of thin-walled cells.

Fruit and seed.—Due to the enlargement of the embryo-sac during post-fertilization stages, much of the nucellus is consumed and only two or three layers persist in the seed (Text-Figs. 68, 70, 71).

The embryo is typically dicotyledonous with well differentiated vascular tissue in the hypocotyl and the cotyledons (Text-Fig. 66). It is surrounded by five to seven layers of endosperm tissue. The seed is dark brown, slightly curved, and its surface is ridged (Text-Fig. 70). The fruit is a three-celled ovoid globose loculicidal capsule containing a single seed in each chamber.

Abnormalities.—In a few cases the microspore "tetrads" showed five to seven microspores instead of the usual four (Text-Fig. 74). This might have resulted from a supernumerary division of one of the microspores or by aberrant meiosis. Polyspory (*see* Maheshwari, 1949, 1950) is known in several plants, *e.g.*, *Cæsalpinia pulcherrima* (Mukherjee,



TEXT-FIGS. 67–78. Figs.–67, 68. Portions of seed coat at the mature embryo-sac stage and nearly mature seed respectively, ×300. Fig. 69. Micropylar part of

ovule, just after fertilization, ×300. Fig. 70. L.s. mature seed (diagrammatic), ×33·3. Fig. 71. Same, transverse section at level *aa* marked in Fig. 70, ×33·3. Fig. 72. Part of aril, ×300. Fig. 73. Part of ovary wall, just after fertilization, ×300. Fig. 74. A polyad "tetrad" with six microspores, ×417. Figs. 75–78. Abnormal embryo-sacs, explanation in text, × 417. (*ar*, aril; *em*, embryo; *end*, endosperm; *ii*, inner integument; *nu*, nucellus; *oi*, outer integument; *vs*, vascular tissue.)

1952), *Cuscuta reflexa* (Johri and Tiagi, 1952), *Solanum macranthum* (Prakash and Chatterjee, 1953), *Lantana camara* (Tandon and Bali, 1955), *Ehretia lævis* (Johri and Vasil, 1956), *Aristolochia* (Johri and Bhatnagar, 1955) *Echinochloa* (Narayanaswamy, 1955), *Justicia simplex* (Ram and Sehgal, 1958), etc.

In a large number of unopened young buds, collected during April and May, 1951, all the floral parts except the ovary had completely aborted. These buds were only 7 mm. in length, *i.e.*, approximately one-fifth of the normal size. The ovules showed healthy embryo-sacs containing the egg and a variable number of free nuclei distributed in the peripheral cytoplasm. The maximum number counted was 32 (Text-Figs. 76–78). The synergids or the antipodals were not traceable. In an eight-nucleate embryo-sac, besides the egg, there were seven dividing nuclei (Text-Fig. 75). These embryo-sacs could be easily mistaken for post-fertilization stages, but I consider them to be unfertilized for the following reasons:—

(*a*) The buds were invariably of a much smaller size than the normal ones.

(*b*) The degenerated floral parts were intact.

(*c*) As the petals and staminal tube fall off soon after the flower opens, the possibility of the flower closing after pollination, as in some tropical plants, does not arise.

(*d*) The presumption that anthers may have opened, brought about self-pollination, and then withered is ruled out by the fact that in most cases the withered anthers contained only degenerated tetrads.

(*e*) There was no indication of pollination and remnants of the pollen tube were not observed in the embryo-sac.

That such abnormalities can occur due to disturbances in external and internal environment is quite likely, since they were met with only in a specific collection made during April and May, 1951.

A few questions suggest themselves. How do the ovules get stimulated and develop without pollination or fertilization? What is the fate of the unfertilized egg and the free nuclei? Do these ovaries develop into fruits? For the present these questions remain unanswered.

Summary and Conclusion

Naregamia alata has solitary axillary, pentamerous and bisexual flowers with a tricarpellary gynœcium.

The androecium consists of 10 stamens united into a tube which is inflated and bladder-like in the apical region.

The anther wall consists of five layers, and the epidermis as well as the fibrous endothecium persist in the mature anther. The tapetum is secretory, and its cells become multinucleate. The reduction divisions are simultaneous as is also the case in *Dysoxylum ramiflorum* (Paetow, 1931), *Azadirachta indica* (Garudamma, 1957), and *Cipadessa baccifera* (Narayana, 1958), but in *Sandoricum kœtjape* (Juliano, 1934 *a*) they are said to be successive. The microspore tetrads are tetrahedral or decussate. The triporate pollen grains are shed at the three-celled stage.

The ovules are bitegmic, crassinucellate and anatropous. A nucellar cap reported in other members of the family by Juliano (1934) and Wiger (1935) is also present in *Naregamia*. An obturator composed of compactly arranged elongated cytoplasmic cells is present. Wiger (1935) stated that in Meliaceæ when the nucellus is weak, only one archesporial cell differentiates but in a strongly developed nucellus several cells assume archesporial character. This is not true in the case of *Naregamia alata* where although the nucellus is massive, the archesporium in most cases consists of a single cell. The development of the female gametophyte conforms to the Polygonum type.

Fertilization is porogamous and remnants of the pollen tube persist for sometime.

Wiger (1935) stated that the development of endosperm in some members of Meliaceæ is autonomous. In *Naregamia alata*, it is quite certain that endosperm development is normally initiated after triple fusion. That this is so also in *Melia azedarach*, *Cedrela toona*, and *Azadirachta indica* has been recently shown by Nair (1956) and Nair and Kanta (1958). The free nuclear condition is followed by wall formation at the heart-shaped stage of the embryo and finally the entire endosperm becomes cellular. The same condition prevails in *Sandoricum kœtjape* (Juliano, 1934 *a*), *Azadirachta indica* (Nair and Kanta, 1958). According to Wiger (1935), in *Dysoxylum* the chalazal portion of the endosperm remains nuclear throughout. This requires confirmation.

Unlike *Sandoricum kœtjape* (Juliano, 1934 *a*), a few layers of endosperm and two or three layers of nucellar tissue persist in the seed.

The development of the embryo conforms to the Crucifer type. The mature embryo is dicotyledonous and both the integuments contribute to the formation of the seed coat.

An aril of parenchymatous cells differentiates from the funiculus and covers part of the ventral surface of the seed.

A few unfertilized embryo-sacs showed a healthy egg and variable number of free nuclei distributed in the peripheral cytoplasm.

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References

* Caparoro, E. 1928. Brevi note sopra gli idioblasti oleiferi nel frutto di *Melia azedarach* L. *Natura (Milano).* **19**: 167–71.

Chang, K. T. and Wang, F. H. 1956. Morphology of pollen grains of Meliaceae. *Acta bot. Sin.* **5**: 253–64.

Garudamma, G. K. 1956. Studies in the Meliaceæ. I. Development of the embryo in *Azadirachta indica* A. Juss. *J. Indian bot. Soc.* **35**: 222–25.

————. 1957. Studies in the Meliaceæ. II. Gametogenesis in *Melia azadirachta* Linn. *Ibid.* **36**: 227–31.

Juliano, J. B. 1934 *a*. Studies in the morphology of Meliaceæ. I. *Sandoricum kætjape* (Burm. F.) Merill. *Philipp. J. Agric.* **23**: 11–48.

————. 1934 *b*. Studies in the morphology of Meliaceæ. II. Steriltiy in Santol, *Sandoricum kætjape* (Burm, F.) Merill. *Ibid.* **23**: 253–66.

Johri, B. M. and Tiagi, B. 1952. Floral morphology and seed formation in *Cuscuta reflexa* Roxb. *Phytomorphology* **2**: 162–80.

—— and Bhatnagar, S. P. 1955. A contribution to the morphology and life-history of *Aristolochia. Ibid.* **5**: 123–37.

—— and Vasil, I. K. 1956. The embryology of *Ehretia lævis* Roxb. *Ibid.* **6**: 134–43.

* Karsten, G. 1891. Über die Mangrove-Vegetation im malayischen Archepele *Bibl. bot.* **22**.

Maheshwari, P. 1949. The male gametophyte of angiosperms. *Bot. Rev.* **15**: 1–75.

————. 1950. *Introduction to the Embryology of Angiosperms*, New York.

Mauritzon, J. 1935. Kritik von J. Wiger's Abhandlung Embryological Studies on the Families Buxaceæ, Meliaceæ, Simarubaceæ and Burseraceæ. *Bot. Notiser.* **1935**: 490–502.

Mukherjee, S. K. 1952. Abnormal microsporocytes in *Cæsalpinia pulcherrima* S.W. *Curr. Sci.* **21**: 290.

Nair, N. C. 1956. Early endosperm development in Meliaceæ. *Sci. and Cult.* **22**: 34–35.

—— and Kanta, Kusum. 1958. Studies on Meliaceæ IV. Floral morphology and embryology of *Azadirachta indica* Juss. A reinvestigation (in Press).

Narayana, L. L. 1958. Floral anatomy and embryology of *Cipadessa baccifera* Miq. *J. Indian bot. Soc.* **37**: 147–54.

Narayanaswamy, S. 1955. Structure and development of the caryopsis in some Indian millets. IV. *Echinochloa frimentacea* Link. *Phytomorphology* **5**: 166–71.

Paetow, W. 1931. Embryologische Untersuchungen an Taccaceen, Meliaceen und Dilleniaceen. *Planta* **14**: 441–70.

PRAKASH, R. AND CHATTERJEE, B. 1953. Cytological study of *Solanum macranthum* Dun. *Curr. Sci.* **22**: 84–85.

RAM MOHAN, H. Y. AND SEHGAL, P. P. 1958. The life-history of *Justicia simplex* Don. *Phytomorphology* **8**: 124–36.

SCHNARF, K. 1931. *Vergleichende Embryologie der Angiospermen*, Berlin.

TANDON, S. L. AND BALI, P. N. 1955. Morphological and cytological studies of the diploid and the naturally occurring triploid *Lantana camara* L. *Indian J. Hort.* **12**: 1–5.

WIGER, J. 1935. *Embryological Studies on the Families Buxaceæ, Meliaceæ, Simarubaceæ and Burseraceæ*, Diss. Lund.

* Not seen in original.

STUDIES ON MELIACEÆ

II. Floral Morphology and Embryology of *Melia azedarach* Linn.—A Reinvestigation

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Introduction

Melia azedarach, the common "Persian Lilac", is a favourite garden tree having delicate foliage and lilac-coloured flowers produced in profusion in axillary panicles. The flowers are generally borne in the earlier part of the dry season—February to April—and the fruits are shed after 10 to 11 months.

The literature on the embryology of Meliaceæ has been reviewed in an earlier communication (Nair, 1959). *Melia candolli*, *M. floribunda*, and *M. azedarach* have been studied by Wiger (1935). According to him the development of endosperm is independent of fertilization and triple fusion. The work of Wiger was adversely criticized by Mauritzon (1935). Recently Garudamma (1956, 1957) studied the embryology of *Melia azadirachta* (= *Azadirachta indica*).

Material and Methods

Material for the present study was collected during 1953–54 from different localities in Pilani. Buds, flowers, and fruits of all stages of development were fixed in formalin acetic alcohol and Navaschin's fixative. Seeds from mature fruits were dissected out and then fixed in F.A.A. and later treated with 10 per cent. hydrofluoric acid in 70 per cent. alcohol for 15 to 20 days to soften the seedcoat. Dehydration and embedding were done in the usual manner. Sections cut at a thickness ranging from 6 to 18 microns were stained in safranin and fast green. Flowers were also castrated and bagged, in March 1957 and they were found to be shed after a few days. The ovaries of these flowers when sectioned did not reveal any feature of interest.

Flower

The bisexual and pentamerous flower has a cylindrical staminal tube enclosing 10 dithecous and introrse anthers within its fimbriate mouth. The gynœcium is pentalocular below becoming unilocular above the middle part. Each carpel bears two rows of superposed ovules; the upper ovules are smaller (Text-Fig. 24).

TEXT-FIGS. 1–28. Fig. 1. Stellate hair from pedicel, ×250. Fig. 2. Branched hair from sepal, ×250. Fig. 3. Unicellular hair from sepal, ×250. Fig. 4. Sessile globular gland, ×333. Fig. 5. Stalked gland from pedicel, ×333. Figs. 6, 7. Secretory cells, ×250. Fig. 8. Organogeny, ×125. Fig. 9. T.S. of young anther lobe showing primary parietal layer and microspore mother cells, ×417. Fig. 10.

Part of anther in L.S. showing wall layers and microspore mother cells, ×417. Fig. 11. Part of anther showing tetrahedral microspore tetrads and anther wall, ×417. Figs. 12, 13. Microspore tetrads, ×417. Fig. 14. Polyad, ×417. Fig. 15. Uninucleate pollen grain, ×417. Fig. 16. Abnormal uninucleate pollen grain, ×417. Fig. 17. Uninucleate pollen grain after shifting the nucleus to the periphery, ×417. Fig. 18. Part of anther showing two-celled pollen grain and fibrous endothecium, ×417. Fig. 19. Mature three-nucleate pollen grain, ×417. Fig. 20. Abnormal three-nucleate pollen grain from an anther having uninucleate pollen grains, ×417. Fig. 21. Germinating pollen grain on the stigma, ×50. Fig. 22. Ovular archesporium, ×417. Fig. 23. Four megaspore mother cells beneath a primary parietal layer, ×417. Fig. 24. L.S. of a carpel showing the differential size of the two ovules inside, ×125. Fig. 25. Functioning megaspore and degenerating remains of megaspores, ×417. Fig. 26. Binucleate embryo-sac, ×417. Fig. 27. Four-nucleate embryo-sac, ×417. Fig. 28. Nearly mature embryo-sac, ×417. (*ca*, carpel; *pe*, petal; *se*, sepal; *st*, staminal tube.)

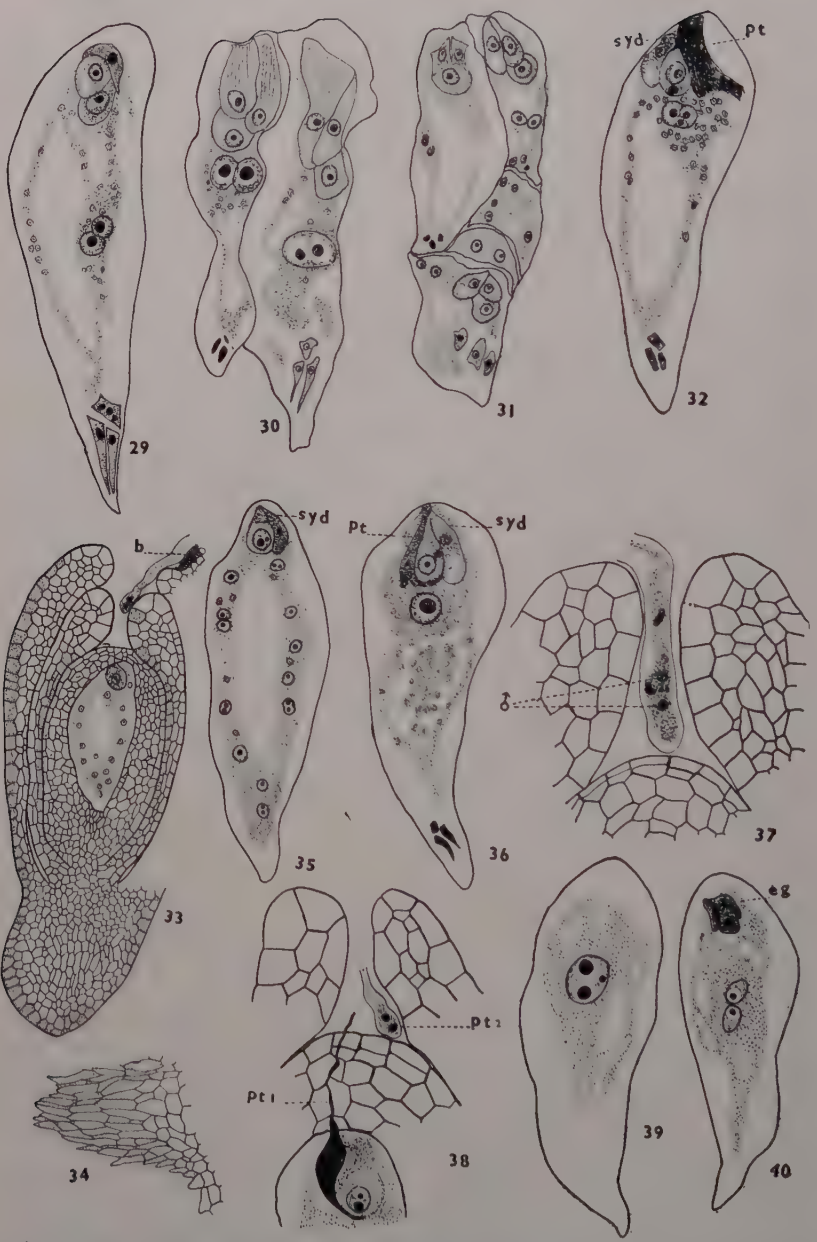
Development of the floral organs is in the sequence sepals, petals, stamens, carpels, and disc (Text-Fig. 8) which is also true of *Sandoricum kœtjape* (Juliano, 1934) and *Naregamia alata* (Nair, 1959).

Floral parts are covered with hairs of various kinds—stellate, unicellular, multicellular, and glandular (Text-Figs. 1–5). Secretory cells are present in all parts of the flower particularly in the disc and the ovary wall. In the earlier stages the secretory cell has dense cytoplasm and large nucleus but during post-fertilization stages it becomes vacuolated (Text-Figs. 6–7).

Microsporangium and Male Gametophyte

In each of the four lobes of the anther differentiates a hypodermal multicelled archesporium. The primary parietal layer formed by the division of the peripheral archesporial cells (Text-Fig. 9) gives rise to four layers of cells—endothecium, two middle layers, and a tapetum—beneath the papillate epidermis (Text-Figs. 10, 11). The endothecium and a few cells in the connective develop fibrous thickenings (Text-Fig. 18). The middle layers are crushed and absorbed. The tapetal cells are uninucleate to begin with but become 2 to 10 nucleate; some of the nuclei subsequently fuse to form irregularly lobed polyploid masses (Text-Figs. 10, 11). Further development conforms to the secretory type. In mature anther the sporangia on either side of the connective become confluent due to the disintegration of the septum.

There are 4 to 6 rows of 12 to 13 microspore mother cells in each microsporangium. The reduction divisions in individual sporangium are synchronous. The spindles of the homotypic division may be either parallel or at right angles to each other resulting in tetrahedral, decussate and isobilateral tetrads (Text-Figs. 11, 13). Cytokinesis takes place by centripetal furrows (Text-Fig. 12). In some cases instead of the usual 4 there were 5 to 7 microspores inside the mother cell wall (Text-Fig. 14). Polyspory has also been recorded in *Naregamia alata* (Nair, 1959). The cells were not of equal size and in one case one of the smaller microspores was enucleate (Text-Fig. 14). Cases of enucleate additional microspores are known in other plants, *e.g.*, *Aristolochia* (Johri and Bhatnagar, 1955).



TEXT-FIGS. 29–40. Fig. 29. A nearly mature embryo-sac, ×417. Fig. 30. Twin embryo-sac, ×417. Fig. 31. A quintuplet, ×417. Fig. 32. Double fertilization, ×417. Fig. 33. Ovule showing free nuclear endosperm and undivided zygote. Note a second pollen tube in the micropyle, ×125. Fig. 34. En-

larged portion marked *b* in Fig. 33, × 333. Fig. 35. Embryo-sac showing 12 free endosperm nuclei, undivided zygote, and degenerating synergid, ×417. Fig. 36. Embryo-sac showing fertilization, ×417. Fig. 37. Porogamous fertilization, ×417. Fig. 38. Fertilized sac an additional pollen tube is seen in the micropyle, ×417. Fig. 39. Embryo-sac having only one healthy nucleus with three nucleoli, ×417. Fig. 40. Embryo-sac with degenerated egg apparatus and healthy polar nuclei, ×417. (*eg*, egg; *pt*, pollen tube; *syd*, synergid.)

The young microspore has dense cytoplasm and large nucleus in the centre (Text-Fig. 15) but due to the formation of a vacuole the nucleus is displaced to one side (Text-Fig. 17). Text-Fig. 18 shows a two-nucleate pollen grain.

A large number of grains remain small and uninucleate at the shedding stage. They stain very lightly and are presumably sterile. Degeneration is frequent at various stages of microsporogenesis. Uninucleate giant pollen grains have been observed in several cases (Text-Fig. 16). In one case a microspore was bilobed and had three nuclei of which one was darkly stained (Text-Fig. 20). This grain was three times bigger than the rest of the uninucleate grains in the anther.

The pollen grains are four-colporate (*cf.*, Erdtman, 1952) and contain abundant reserve food that mask the nuclei. In a few grains, however, three nuclei could be observed with clarity (Text-Fig. 19), and therefore it is regarded that the pollen grains are shed at the three-nucleate stage. Wiger (1935) reported two-nucleate pollen grains in *Melia* species.

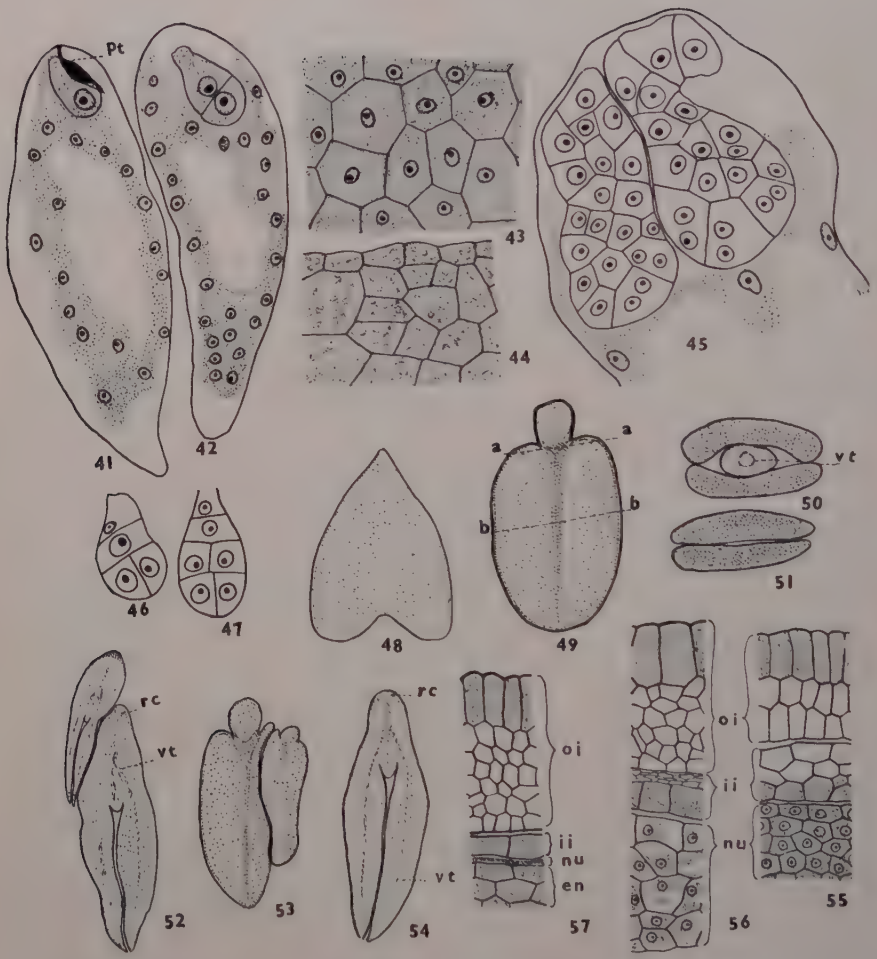
Megasporangium

The ovular primordium is at first straight but gradually curves up and becomes anatropous (Text-Fig. 24). The inner integument develops first followed by the outer. Both are three-layered except in the tip where they are massive (Text-Fig. 33). The outer layer of cells of the outer integument and the inner layer of the inner integument contain tanin. Micropyle is formed by the inner integument (Text-Fig. 24). Wiger (1935) stated that the nucellus of the upper ovules protrudes out of the micropyle. In my material only very rarely the tip of the nucellus was naked due to the failure of the integuments to reach the apex.

The vascular strand supplying the ovule can be marked out at the tetrad stage. It terminates at the chalazal end, at the level of origin of the integuments (Text-Fig. 24). The cells at the chalazal end of the ovule divide actively and thus the distance between the basal limit of the inner integument and chalaza increases. The epidermal cells of the funicle are elongated and rich in protoplasmic contents (Text-Fig. 34) and serve to conduct the pollen tube to the ovules.

Megasporogenesis

A group of hypodermal archesporial cells differentiate in the young nucellus when microspore mother cells enter reduction division (Text-Fig. 22). Wiger (1935) also reported multicellular archesporium in



TEXT-FIGS. 41–57. Fig. 41. Free endosperm nuclei, undivided zygote, and remains of pollen tube, ×417. Fig. 42. Two-celled embryo and free nuclear endosperm, ×417. Fig. 43. Cellular endosperm, ×417. Fig. 44. Endosperm in mature seed, ×417. Fig. 45. Twin embryo and free nuclear endosperm, ×417. Figs. 46–48. Stages in the development of embryo. Fig. 48. (dissected), ×21. Rest, ×417. Fig. 49. Dissected mature embryo, ×12·5. Figs. 50, 51. T.S. of embryo marked *aa*, *bb*, in Fig. 49, ×12·5. Figs. 52, 53. Twin embryo, ×12·5. Fig. 54. L.S. of embryo, ×12·5. Figs. 55–57. Development of seed-coat, ×417. (*en*, endosperm; *ii*, inner integument; *nu*, nucellus; *oi*, outer integument; *pt*, pollen tube; *rc*, root cap; *vt*, vascular trace.)

Melia species. The nucellar epidermis divides once periclinally (Text-Figs. 37, 38). The primary parietal layer derived from the peripheral archesporial cells divide repeatedly to produce 6 to 8 layers of parietal tissue. The growing embryo-sac destroys some of the cells and at the time of fertilization the embryo-sacs in the lower and upper ovules are 3 to 5 and 2 to 3 layers deep respectively. Only one of the megaspore mother cells usually develops further giving rise to linear or T-shaped tetrad. Wiger (1935) observed only linear tetrads in *Melia* species. Of the four spores the chalazal one functions (Text-Fig. 25). Occasional occurrence of contiguous linear tetrad is reported by Wiger (1935). The development of embryo-sac conforms to the Polygonum type (Text-Figs. 25–28).

Female Gametophyte

The mature embryo-sac has a broad micropylar part and a narrow chalazal end (Text-Figs. 28, 29). The synergids are hooked and possess basal vacuoles and apical nuclei. They are ephemeral and degenerate soon after fertilization. But in a few cases one of the synergids was seen to persist for a longer time (Text-Fig. 35). Egg is flask-shaped and has the usual organization. The polar nuclei meet in the centre of the sac and fuse, and the secondary nucleus takes a place close below the egg (Text-Figs. 28, 29, 32, 36). The antipodals are organized as cells; the third one lies anterior to the other two (Text-Fig. 29). The antipodals persist till fertilization and degenerate afterwards (Text-Figs. 32, 36, 41). There are plenty of starch grains in the vicinity of the egg apparatus and secondary nucleus.

Multiple Embryo-sacs

Several cases of twin embryo-sacs triplets and quadruplets have been observed. Text-Figure 30 shows two mature embryo-sacs lying side by side. The most interesting case was that of an ovule having five embryo-sacs (Text-Fig. 31). Four of these sacs were lying more or less in a linear fashion while the other was on one side. One sac was binucleate, three were mature and the fifth one had five nuclei. The quintuplets were spread in four sections and therefore it is possible that some of the nuclei might have been lost while sectioning.

Pollination and Fertilization

Cross-pollination seems to be the rule. Germinating pollen grains have been observed on the stigmatic surface (Text-Fig. 21). The pollen tube comes out through one of the germ pores and move down the stylar canal, lined with transmitting tissue. The stylar canal is often crowded with dark staining remnants of pollen tubes. Fertilization is porogamous (Text-Figs. 33, 37, 38). The tube enters the embryo-sac by demolishing one of the synergids (Text-Figs. 32. 36). X-bodies are present in the discharged end of the pollen tube (Text-Fig. 36). Syngamy and triple fusion have been observed (Text-Fig. 32).

In several cases remnants of pollen tubes were present in the micropylar region. In one ovule two tubes had entered the micropyle; one had discharged the sperms in the embryo-sac while the other had reached only up to the nucellus (Text-Fig. 38). In another ovule in which fifteen endosperm nuclei had been formed was seen in the micropylar region a pollen tube with two sperms (Text-Fig. 37). The entry of accessory pollen tubes is not a very rare phenomenon in angiosperms (*see* Maheshwari, 1950). Recently it has been reported in *Tamarix* (Johri and Kak, 1954) and *Cedrela toona* (Nair, 1956).

The pollen tube is ephemeral but sometimes it persists after fertilization till some free endosperm nuclei have been formed (Text-Fig. 41). Persistent pollen tubes are also found in other members of the family (Nair, 1959).

Endosperm

The primary endosperm nucleus divides earlier than the fertilized egg and produces two free nuclei. These move apart and soon divide repeatedly to form a large number of free nuclei that are arranged in the peripheral cytoplasm (Text-Figs. 35, 41, 42). In the chalazal end there is an aggregation of nuclei (Text-Fig. 42). Wall formation is initiated when embryo has become heart-shaped. The growing embryo consumes the endosperm and in a mature seed, only the peripheral 8 to 9 layers of cells are found around the embryo. At first the cells have prominent nuclei and light cytoplasm (Text-Fig. 43). In the mature seed the endosperm cells contain oil and stain very deep (Text-Fig. 44).

Embryo

The zygote divides only after the endosperm has well advanced. It enlarges, becomes vacuolated and divides transversely (Text-Fig. 42) to form a basal and a terminal cell. Text-Figures 46 to 48 show proembryos but the sequence of cell divisions leading to their formation could not be traced. The mature embryo consists of two fleshy cotyledons and an axis bearing the plumule and radicle (Text-Figs. 49–51, 54). The radicle shows the presence of root cap (Text-Fig. 54).

Seed

During post-fertilization stages the integuments and nucellus undergo considerable changes and modifications. At the time of fertilization both the integuments are three-layered (Text-Fig. 55). While the outer epidermal cells of the outer integument slightly elongate radially, the other two layers divide actively to produce 6 to 7 layers of cells (Text-Fig. 56). The tanniniferous inner epidermis of the inner integument alone persists as the inner seedcoat and the other two layers are crushed and absorbed (Text-Fig. 57). Thus my observations are in agreement with that of Wiger's (1935) account.

The growing endosperm consumes the nucellus and in the mature seed the latter persists in the form of a scanty streak of perisperm (Text-Fig. 57).

The embryo occupies more or less full length of the seed. The vascular elements in the embryo can be clearly distinguished in the form of procambial strands (Text-Figs. 52, 54).

Degeneration and Sterility

More than 50 per cent. of the ovules examined had degenerated gametophytes. In many cases only the polar nuclei (secondary nucleus if fusion has taken place) remain healthy (Text-Fig. 40) due to the degeneration of the egg apparatus and antipodals and if pollen tube enters the embryo-sac only triple fusion takes place (*see* Nair, 1956). Often the healthy nuclei had three, two large and one small, nucleoli (Text-Fig. 39). Ex-embryonate seeds are frequent and they have crumpled appearance.

Polyembryony

Text-Figures 45, 52, 53 show twin embryos. The larger embryo in Fig. 45 seems to be zygotic and the additional one might have been developed from one of the synergids. Polyembryony has also been recorded in *Azadirachta indica* (Garudamma, 1956; Nair and Kanta, 1958).

Discussion

Wiger (1935) stated that most of his species showed only a single row of microspore mother cells in each anther lobe. He does not mention anything specifically about *Melia* species. In my material there were 4 to 6 rows of microspore mother cells. In the family more than four rows of microspore mother cells are known in *Dysoxylum ramiflorum* (Paetow, 1931), *Sandoricum kœtjape* (Juliano, 1934), and *S. indicum* (Nair, 1958). In *Carapa guanensis*, *C. molucensis*, and *Azadirachta indica* (Schnarf, 1931; Garudamma, 1957), there is only a single row of cells. *Naregamia alata* has one or two rows of microspore mother cells (Nair, 1959).

The crassinucellate ovule is bitegmic and the development of the embryo-sac is of the polygonum type as reported earlier. According to Wiger (1935) the synergids in the family are mostly egg-like, in the position of the nucleus and vacuole. As in *Dysoxylum* (Paetow, 1937), *Sandoricum* (Juliano, 1934), *Azadirachta indica* (Garudamma, 1959; Nair and Kanta, 1958) and *Naregamia alata* (Nair, 1959) the synergids in my material had apical nuclei and basal vacuoles.

Wiger observed the tendency to produce multiple embryo-sacs in *Melia* species. In the present study several cases of multiple embryo-sacs have been observed. It appears that they have been produced as a result of the activity of one or more megaspore mother cells.

Wiger (1935) stated that the oospore and the primary endosperm nucleus divide almost simultaneously. In my material the zygote divides only after a large number of free endosperm nuclei have been formed. This is also true of *Sandoricum kœtjape*, *S. indicum*, *Naregamia alata* and *Azadirachta indica* (Juliano, 1934; Nair, 1958, 1959; Nair and Kanta, 1958).

One of the chief interests in the embryology of Meliaceæ lies in Wiger's report of the autonomous development of endosperm in some members. This according to Gustafsson (1946, 1947 *a*, *b*) and Maheshwari (1950) is a very rare phenomenon. The statements of Wiger (1935) may be summarized by a few quotations from his work:—

1. "No doubt double fertilization takes place in this family. The *Melia* species have often failed to produce embryos although fertilized.* Of the egg apparatus only the almost empty cellulose walls then remained and the endosperm nucleus has not yet divided.* In many cases the latter divides and gives nuclear endosperm. Such ovules I have seen in *Melia*. They grow out unfertilized but lacking embryos (Wiger, 1935, p. 65).

2. "The upper ovule in the ovary chamber does not grow out. After the embryo-sac is built they abort.... Fertilization and embryo formation does not take place but an ephemeral nuclear endosperm of a few nuclei may be formed. I saw in such an abortive ovule six endosperm nuclei (p. 66).

3. "Double fertilization no doubt exists in Meliaceæ although I have not seen the nuclear fusion. The division of primary endosperm nucleus is evidently independent of fertilization or division of egg cell. In many embryo-sacs I have seen endosperm without any trace of fertilization (p. 66)."

The validity of Wiger's assertions has been questioned by Mauritzon (1935). As pointed out by him (Mauritzon, 1935), fertilized egg may divide very late and traces of fertilization are frequently not evident after it has taken place. It has been shown earlier that the oospore in *Melia azedarach* divides very late. This is also true of *Sandoricum kœtjape* (Juliano, 1934), *S. indicum*, *Naregamia alata*, *Cedrela toona* and *Azadirachta indica* (Nair, 1956, 1958, 1959; Nair and Kanta, 1958). Cases of secondary nucleus being fertilized, while egg is not, are known. In such cases a nuclear endosperm may result without the development of an embryo. In view of the above considerations it is quite likely that the embryo-sacs ascribed by Wiger (1935) to the pre-fertilization stages may actually belong to post-fertilization stages. The endosperm formation in my material is initiated only after triple fusion is quite certain. The evidences in favour of such an inference are: (*a*) triple fusion has been observed in many cases, (*b*) several

* Mauritzon (1935) says that this is due to degeneration, and fertilization did not actually take place.

preparations clearly showed remnants of pollen tubes in the micropylar region of ovules showing early endosperm development, and (*c*) no endosperm is formed in ovules from flowers that have been emasculated and bagged.

Wiger (1935) stated that the upper ovules abort after the mature embryo-sac stage has been reached and consequently no fertilization takes place in these ovules. But in my material many of the upper ovules were fertilized and had developed embryos. Text-Figure 58 is drawn from such an upper ovule.

Summary

Melia azedarach has panicled axillary inflorescence. The pinkish and pentamerous flowers have each a cylindrical staminal tube bearing dithecous introrse anthers. Each carpel has four ovules in two rows.

The archesporium in the anther consists of 4 to 6 rows of 12 to 13 microspore mother cells each. A persistent epidermis, a fibrous endothecium, two ephemeral middle layers and a multinucleate secretory tapetum constitute the anther wall. Reduction divisions are simultaneous and tetrahedral, decussate or isobilateral tetrads are formed. Polyspory is frequent. Pollen grains are shed at the three-nucleate stage.

The ovules are bitegmic and crassinucellate. The micropyle is formed by the inner integument. The archesporium is multicellular. The development of the embryo-sac is of the Polygonum type. Antipodals degenerate soon after fertilization. A few cases of multiple embryo-sacs have been observed. Degeneration of gametophytes is frequent.

Fertilization is porogamous. Syngamy and triple fusion have been observed. The primary endosperm nucleus divides earlier than the zygote. Endosperm is of the free nuclear type. A few layers of endosperm cells remain around the embryo.

The zygote divides when the endosperm is well advanced. The mature embryo is dicotyledonous. A few cases of polyembryony have been observed.

The seed has 7 to 8-layered outer seedcoat and a single layered inner seedcoat.

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References

ERDTMAN, G. 1952. *Pollen Morphology and Plant Taxonomy*, Waltham, Mass., U.S.A.

GARUDAMMA, G. K. 1956. Studies on Meliaceæ. I. Development of the embryo in *Azadirachta indica* A. Juss. *J. Indian bot. Soc.* **35**: 222–25.

————. 1957. Studies in Meliaceæ. II. Gametogenesis in *Melia azadirachta* Linn. *Ibid.* **36**: 227–31.

JOHRI, B. M. AND KAK, D. 1954. The embryology of *Tamarix* Linn., *Phytomorphology* **4**: 230–47.

—— AND BHATNAGAR, S. P. 1955. A contribution to the morphology and life-history of *Aristolochia*. *Ibid.* **5**: 123–37.

GUSTAFSSON, Å. 1946. Apomixis in higher plants. I. The mechanism of apomixis. *Lunds Univ. Årsskr.* N.F. Avd. II. **42**: 1–67.

————. 1947 *a*. Apomixis in higher plants. II. The casual agent of apomixis. *Ibid.* **43**: 71–179.

————. 1947 *b*. Apomixis in higher plants. III. Biotype and species formation. *Ibid.* **43**: 183–370.

JULIANO, J. B. 1934. Studies on the morphology of Meliaceæ. I. *Sandoricum kætjape* (Burm. F.) Merill. *Philipp. J. Agric.* **23**: 11–48.

MAHESHWARI, P. 1950. *An Introduction to the Embryology of Angiosperms*, McGraw Hill, New York.

MAURITZON, J. 1935. Kritik von J. Wiger's Abhandlung "Embryological studies on the families Buxaceæ, Meliaceæ, Simarubaceæ, and Burseraceæ. *Bot. Notiser* **1935**: 490–502.

NAIR, N. C. 1956. Early endosperm development in Meliaceæ. *Sci. & Cult.* **22**: 34–35.

————. 1958. Studies on Meliaceæ. III. Floral morphology and embryology of *Sandoricum indicum. Cav. Phyton.* **10** : 145–151.

————. 1959. Studies on Meliaceæ. I. Floral morphology and embryology of *Naregamia alata* W. & A. *J. Indian bot. Soc.* **38**: 351–364.

—— AND KANTA, KUSUM. 1958. Studies on Meliaceæ. IV. Floral morphology and embryology of *Azadirachta indica* Juss. A reinvestigation (in Press).

PAETOW, W. 1931. Embryologische Untersuchungen an Taccaceen, Meliaceen und Dilleniaceen. *Planta* **14**: 441–70.

SCHNARF, K. 1931. *Vergleichende Embryologie der Angiospermen*, Berlin.

WIGER, J. 1935. *Embryological Studies on the Families Buxaceæ, Meliaceæ, Simarubaceæ and Burseraceæ*, Diss. Lund.

OBSERVATIONS ON A VIRUS DISEASE OF GARDEN NASTURTIUM (*TROPAEOLUM MAJUS* L.) OCCURRING IN NAINI TAL

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Two varieties of garden nasturtiums are common in private gardens in Naini Tal. Both are trailers, one has double flowers and the other single. Plants with double flowers have several rows of petals and the characteristic spur is missing. No seeds are set in this variety, which is propagated by cuttings. The writers have not come across any plant of this variety which is virus free.

For the last two years a disease characterised by severe mosaic symptoms together with necrotic spots has been noticed in the double variety. Sporadic plants with the disease have been seen in the single variety also. The infected leaves show severe mottling, vein-banding, crinkling and puckering, and often necrotic spots. There is also a colour-break in the petals consisting of yellow streaks which stand out clearly against the orange background.

Experimental

Host range

The virus has been successfully transmitted to several species of plants by rubbing the sap from a diseased plant to healthy seedlings using carborundum as an abrasive. The plants successfully inoculated together with the symptoms produced are given below:—

Tropaeolum majus (Garden nasturtium).—Symptoms appear about 6 days after inoculation as small dark-green areas on light-green background. These later fuse to give a mosaic pattern (Plate X, Fig. 1). Sometimes dark-green vein-banding appears, which then diffuses into the adjoining areas and is accompanied by scattered, necrotic spots. The older leaves become distorted and crumpled.

Nicotiana glutinosa.—On the inoculated leaves necrotic rings and spots appear after 5–6 days (Plate X, Fig. 2), but tend to disappear later. Systemic symptoms consist of light-green or yellowish spots together with a mottle. Systemically invaded leaves also show necrotic rings after prolonged periods. The leaves are distorted and the plant stunted.

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Nicotiana debneyi.—Infected leaves show necrotic rings about 10–15 days after inoculation.

Nicotiana rustica and *N. tatacum* var. White Burley—Inoculated leaves show numerous small chlorotic circular spots after about 10–15 days. These soon disappear and the systemic symptoms consist of mottling and mosaic patterns on the younger leaves. Sometimes necrotic ringspot symptoms appear on the inoculated leaves.

Capsicum frutescens.—Symptoms on the inoculated leaves appear as chlorotic rings and systemically invaded leaves show mosaic mottling (Plate X, Fig. 3).

Petunia sp.—Leaves become mottled about 6 days after inoculation (Plate X, Fig. 4), and later become distorted.

Vicia faba (Broad bean).—Inoculated leaves show no clear symptoms. Systemic symptoms appear about 9 days after inoculation and consist of dark-green spots on light-green background. The spots increase in size and fuse with each other to produce a severe mottling (Plate X, Fig. 5). Affected leaves are distorted and the whole plant is weak and stunted.

The leaves of two varieties of *Nicotiana tabacum*, *viz*., Harrison special and Havana, were inoculated with the infective sap, but all attempts to get infection failed. Similarly inoculated plants of *Zinnia elegans*, *Cucumis sativus*, *Cucurbita maxima*, *Raphanus sativus*, *Chenopodium* sp., *Phaseolus vulgaris*, *Vigna sinensis*, *Dolichos lablab*, *Solanum nigrum*, *Solanum melongena* did not show any symptoms and remained uninfected.

Physical Properties

Dilution end point.—Sap from diseased nasturtium plants diluted in distilled water caused infection in nasturtium plants at dilutions up to 1 : 100 and not at 1 : 1,000.

Thermal inactivation point.—2 ml. of sap from diseased nasturtium plants, in thin-walled tubes, were maintained at a given temperature for 10 minutes in a water-bath. The sap was then rapidly cooled and rubbed on to the leaves of 5 nasturtium plants. The thermal inactivation point of the virus lay between 50–55° C.

Resistance to ageing.—The sap from diseased nasturtium plants was kept at room temperature (22° C.) for various periods during summer. A batch of five nasturtium plants was inoculated after every 24 hours. The virus retained its infectivity for 24 hours only.

Insect Transmission

Of three species of aphids, namely, *Myzus persicae* Sulz., *Brevicoryne brassicae* L. and *Macrosiphum pisi* Kalt., used in insect transmission experiments *Myzus persicae* and *Brevicoryne brassicae* transmitted the

virus from diseased to healthy nasturtium plants. The virus is of non-persistent type and can be acquired by the vectors in short feeding periods.

Identity of the Virus

So far two viruses have been described on garden nasturtiums. Jensen (1950) reported nasturtium mosaic virus causing a disease in California and Silberschmidt (1953) described a similar disease of nasturtium from Brazil. This virus has a very limited host range, the only two hosts reported so far are *Zinnia elegans* and *Tropaeolum majus*.

The other virus, reported by Smith (1949, 1950 and 1957) from Cambridge, England, produces ringspot symptoms on *Nicotiana glutinosa* and *Nicotiana tabacum*: it has a wider host range than nasturtium mosaic virus and infects plants belonging to different families.

The virus in the present study broadly resembles nasturtium ringspot virus described by Smith. It differs from the previously described strain in producing colour-break in the petals, in not infecting two varieties of *Nicotiana tabacum* tested, but is able to produce disease in other species of *Nicotiana* namely, *N. glutinosa*, *N. rustica* and *N. debneyi*. The present strain differs slightly in its physical properties also. It is probable that it is a different strain of nasturtium ringspot virus.

Summary

A virus disease of garden nasturtiums characterised by vein-banding, mosaic mottling and puckering of leaves has been noticed in gardens in Naini Tal. Apart from garden nasturtium the virus has been transmitted experimentally to 8 species of plants belonging to Solanaceæ and Leguminosæ. It is of non-persistent type and is transmitted by *Myzus persicae* Sulz., and *Brevicoryne brassicae* L. but not by *Macrosiphum pisi* Kalt. The virus seems to be a strain of nasturtium ringspot virus described by Smith (1957).

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References

Jensen, D. D. 1950. Nasturtium mosaic, a virus disease of *Tropaeolum majus* L. in California. *Phytopathology* (Abstr.) **40**: 967.

Silberschmidt, K. 1953. Studies on a mosaic of nasturtium occurring in Brazil. *Phytopathology* **43**: 304–08.

Smith, K. M. 1949. Virus and virus diseases. Master Memorial Lectures. *J. R. hort. Soc.* **74**: 521–28.

SMITH, K. M. 1950. Some new virus diseases of ornamental plants. *Ibid.* **75**: 350–53.

———. 1957. *A Text-Book of Plant Virus Diseases.* J. & A. Churchill Ltd., London.

EXPLANATION OF PLATE X

FIG. 1. Two leaves of garden nasturtium. One on the right is healthy, the other on the left shows mosaic symptoms.

FIG. 2. Infected leaf of *N. glutinosa* showing mosaic symptoms.

FIG. 3. Infected leaf of *Capsicum* showing mosaic mottling.

FIG. 4. Healthy and diseased Petunia leaves.

FIG. 5. A diseased twig of broad bean showing systemic infection.

K. S. Bhargava and R. D. Joshi FIGS. 1-5

VELAMEN IN TERRESTRIAL MONOCOTS

I. Ontogeny and Morphology of Velamen in the Liliaceæ

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Introduction

The peculiar development of epidermis into a special tissue velamen was until recently thought to be restricted to epiphytic and some terrestrial members of families Orchidaceæ and Araceæ. Göebel (1922) recorded velamen in a few members of terrestrial monocotyledonous families like Liliaceæ, Amaryllidaceæ, Dioscoreaceæ, Taccaceæ, Commelinaceæ and Iridaceæ, and stressed the need for a thorough investigation of velamen in purely terrestrial plants rather than in members of Orchidaceæ and Araceæ. Engard's (1944) contribution to the study of velamen in terrestrial orchids is worthy of mention. Recently Mulay and Deshpande (1952) studied velamen in some species of *Asparagus*. Deshpande (1955) observed velamen in some members of Amaryllidaceæ. Mulay *et al.* (1956, *a*, *b*, *c* and 1958) have contributed to the study of velamen in some terrestrial and epiphytic orchids.

Materials and Methods

Material for the present study was collected during Botanical excursions from Birla College. Some species were obtained from Botanical Gardens like Lalbagh, Bangalore; Lloyd Botanic Gardens, Darjeeling; Government Botanic Gardens, Ootacamund and Sajjan Bagh, Udaipur. The specimens of *Sansevieria thyrsiflora* and *S. hahnii* were kindly made available to the authors by Dr. Hecht of State College of Washington.

The following species were investigated:—

Name of Species	Tribe
1. *Aspidistra lurida* Baker ..	Aspidistreæ
2. *Polygonatum oppositifolium* Royle	Polygonatæ
3. *Tupistra clarkei* Hook. ..	Aspidistreæ

	Name of Species	Tribe
4.	*Hemerocallis fulva* Linn.	Hemerocallideæ
5.	*H. flava* Linn.	Hemerocallideæ
6.	*Dracæna aungustifolia* Roxb.	Dracæneæ
7.	*Chlorophytum elatum* R. Br.	Asphodeleæ
8.	*C. orchidastrum* R. Br.	Asphodeleæ
9.	*C. sternbergianum* R. Br.	Asphodeleæ
10.	*Anthericum variegatum* Hort. ex. Fl.	Asphodeleæ
11.	*Lilium tuberosum*	Tulipeæ
12.	*Ruscus hypophyllum* Linn.	Rusceæ
13.	*Sansevieria thyrsiflora* Thunb.	Ophiopogoneæ
14.	*S. hahnii*	Ophiopogoneæ
15.	*Asparagus adscendens* Roxb.	Asparageæ

Usual procedures of fixing, dehydration and embedding were followed. Safranin and fast green. crystal violet and erythrosin, and iron hæmatoxylin were used as stains.

Observations

Velamen layers vary from one to ten. The following table gives the name of the species and number of velamen layers found in each:

	Name of the Plant	Number of layers
1.	*Aspidistra lurida*	Four to five
2.	*Polygonatum oppositifolium*	Two
3.	*Tupistra clarkei*	One
4.	*Hemerocallis flava*	Two to three
5.	*H. fulva*	One
6.	*Dracæna aungustifolia*	One
7.	*Chlorophytum elatum*	One

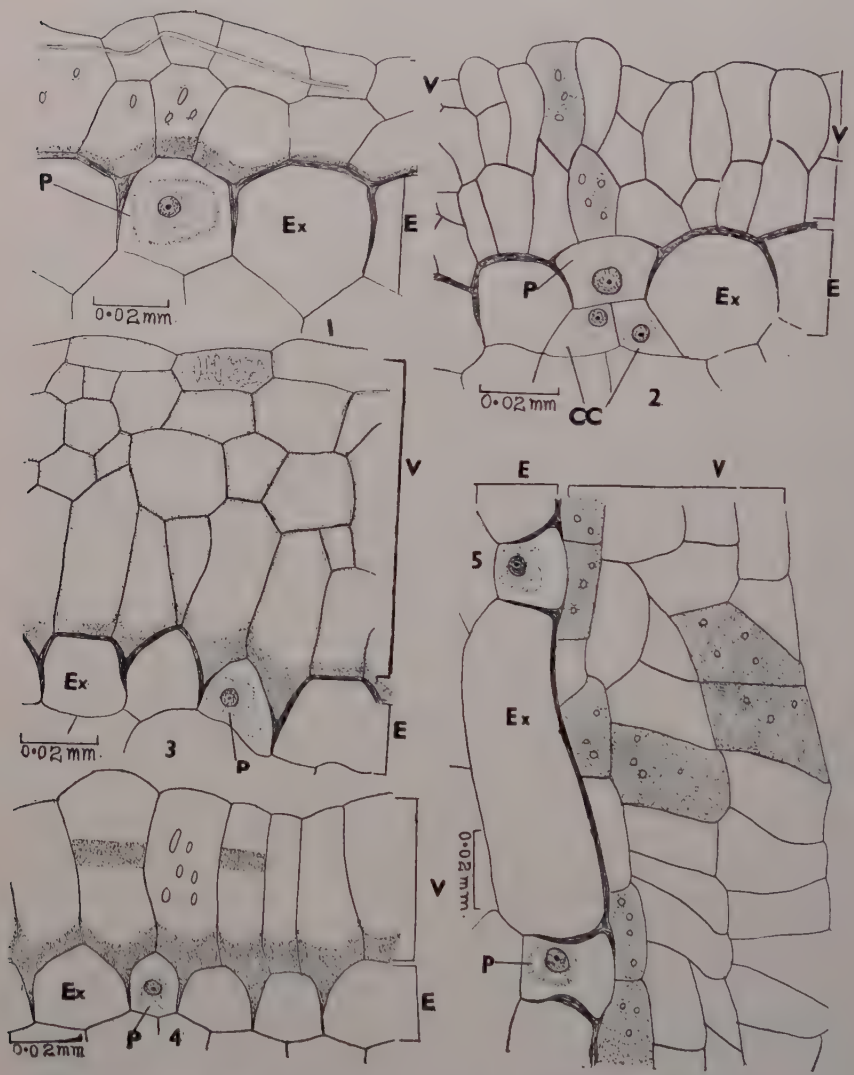
	Name of the Plant	Number of layers
8.	*C. orchidastrum*	One
9.	*C. sternbergianum*	One
10.	*Anthericum variegatum* ..	One
11.	*Lilium tuberosum*	One
12.	*Ruscus hypophyllum*	One
13.	*Sansevieria thyrsiflora*	Three
14.	*S. hahnii*	One
15.	*Asparagus adscendens*	Eight to ten

One-layered velamen develops by anticlinal divisions of protoderm, and more than one-layered by periclinal divisions. To begin with all the velamen cells possess prominent nuclei and dense cytoplasm. For a considerable distance from the apical region, velamen is surrounded by root cap tissues (Pl. XI, Fig. 1). At the level where root cap begins to disappear the velamen cells start vacuolation. After vacuolation velamen cell-walls are thickened.

Exodermis and endodermis are seen to arise at the same level at the apex. Exodermis remains uniseriate during further development. At the level at which velamen cells start vacuolating exodermal layer differentiates into long and short cells (Pl. XI, Fig. 2). Long cells lose the protoplasmic contents; however, short cells retain them. After complete vacuolation of exodermal cells deposition of different wall lalyers starts.

Internal Features

Velamen in all the cases is characterised by simple pits (Text-Figs. 1 and 2). In majority of cases tangential and radial walls of velamen cells are uniformly thick or thin but in a few species like *Sansevieria thyrsiflora* (Text-Fig. 2) the tangential walls of first layer are thin and of second layer thick. Other morphological peculiarity is the presence of stainable granular matter which occurs in *Polygonatum* (Text-Fig. 1), *Tupistra* and *Aspidistra* (Text-Fig. 3). Sometimes granular matter in case of *Tupistra* forms thick strips in the middle of velamen cells (Text-Fig. 4). These granules sometimes leave empty spaces as in *Aspidistra lurida* (Text-Fig. 3) and also in *Hemerocallis fulva*. Sometimes these granules form a thin lining along the walls of velamen cells giving them ridged appearance (Text-Fig. 3). In many cases the outermost layer of velamen cells produces root hairs which disappear in



TEXT-FIGS. 1–5. Fig. 1. Portion of root of *Polygonatum oppositifolium* in t.s. showing velamen with pits. Granular matter is present along the exodermis. Exodermal walls are striated. Fungal hyphæ are also seen. *ex* = exodermal cell; *p* = passage cell. Fig. 2. Portion in t.s. of *Sansevieria thyrsiflora* showing velamen in t.s. with pits. Complementary cells are present beneath the passage cell. *cc* = complementary cells. Fig. 3. Portion of root of *Aspidistra lurida* in t.s. showing granular matter in velamen cells as well as along the outer tangential walls of the exodermis. Fig. 4. Portion of root of *Tupistra clarkei* in t.s. showing thick strips of granular matter in velamen cells. Fig. 5. Portion of root of *Sansevieria thyrsiflora* in l.s. showing radially elongated velamen cells.

the older portions of the root, but in some cases they are present for quite a considerable length and sometimes become lignified.

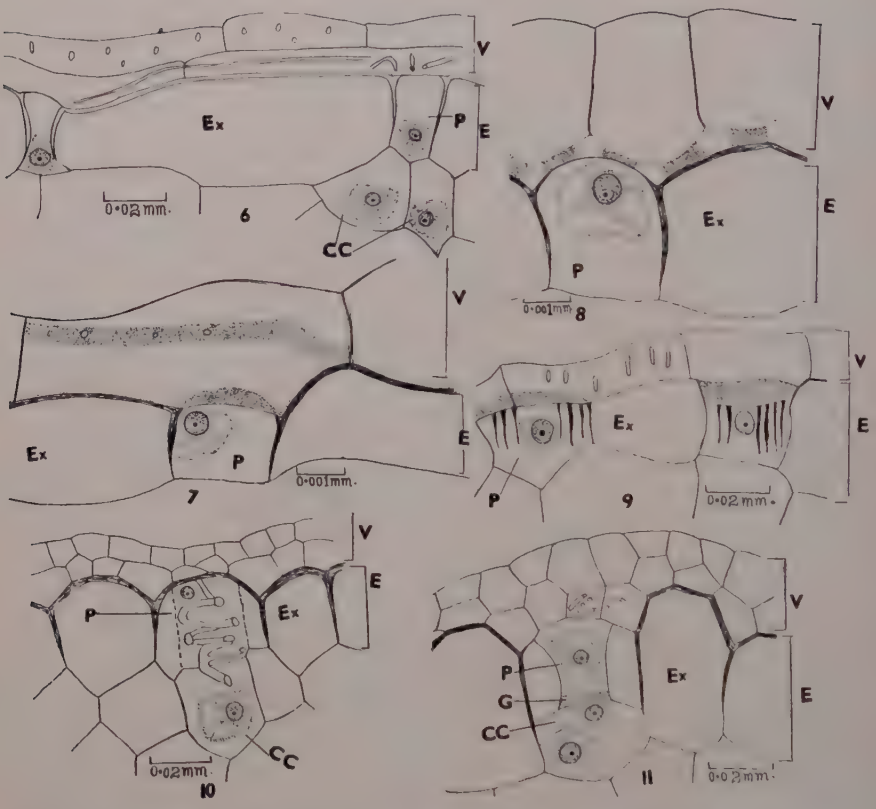
In the longitudinal view velamen cells may be either elongated in the direction of the root or radially elongated (Text-Figs. 5 and 6). Velamen cells reveal folds and pits on longitudinal walls as in *Dracæna* and *Asparagus* (Pl. XI, Figs. 3 and 4).

Velamen is delimited from the cortex by a uniseriate layer of exodermis. Its cells are roughly diamond-shaped (Text-Fig. 1). The outer tangential wall of the exodermal cells is thick and striated (Text-Figs. 5 and 6) and that of the passage cell is usually thin. In some cases as in *Hemerocallis fulva* the outer tangential wall of the passage cells is thick. Sometimes there are pits on the outer tangential walls of exodermal cells. An interesting feature is the occurrence of granular matter all along the outer tangential walls of the exodermis. This granular matter aggregates densely over the passage cells to form pads. Such pads are present in *Tupistra clarkei*, *Polygonatum oppositifolium* and *Aspidistra lurida*. In many cases this granular material is localized over the outer tangential walls of the exodermis as in *Hemerocallis fulva* and *Lilium tuberosum* (Text-Fig. 8).

In longitudinal view exodermal cells are elongated along the root axis. Passage cells retain their shape, appear short and are arranged in vertical rows usually interposed among the exodermal cells. The radial walls of both exodermal as well as passage cells are thick and taper towards the cortex. In many cases as in *Ruscus hypophyllum* and *Dracæna aungustifolia* there are elongated pits on exodermal cell walls (Pl. XI, Figs. 4 and 5). Sometimes there are cross-marks in exodermal cells as seen in *Polygonatum oppositifolium*, *Ruscus hypophyllum*, *Hemerocallis flava* and *Anthericum variegatum*. Occasionally passage cells have transverse marks in *Anthericum variegatum* (Text-Fig. 9).

Mycorrhizal fungus is present in abundance in all the members studied. Fungal hyphæ find their entry to the velamen through root hairs where they ramify. These hyphæ pass on to the cortex through the passage cells. Sometimes they take a spiral course in the passage cell as in *Hemerocallis flava* (Text-Fig. 11).

Another feature of interest is the presence of two small cover cells just above the passage cell which are formed from the velamen cells. Just beneath the passage cells also there occur one or two small cells called complementary cells which are formed from the passage cell. These cells possess nuclei and cytoplasm. Occurrence of only one complementary cell has been observed in *Hemerocallis flava* (Text-Fig. 11). This complementary cell may have its own pad of granular matter towards exodermis (Text-Fig. 11). In all the essential features they resemble the true passage cells.



TEXT-FIGS. 6–11. Fig 6. Portion of root in l.s. showing elongated velamen cells in *Hemerocallis flava*. Fig. 7. Portion of root of *Lilium tuberosum* in l.s. showing ridged appearance of exodermal outer tangential wall. Fig. 8. Portion of root of *Lilium tuberosum* in t.s. showing localised arrangement of granular matter in strips. Fig. 9. Portion of root of *Anthericum variegatum* in l.s. showing transverse marks in passage cell. Fig. 10. Portion of root of *Hemerocallis flava* in t.s. showing passage cell with fungal hyphæ which takes a spiral course in passage cell. Fig. 11. Portion of root of *Hemerocallis flava* in t.s. showing single complementary cell with a granular pad. *cc* = complementary cell; *g* = granular pad.

DISCUSSION

The fact that velamen is the product of protoderm is confirmed by the present study. Haberlandt (1914), Engard (1944) and Mulay *et al.* (1956 *a*, *b*, *c* and 1958) are also of the same view based upon their study of velamen in orchids.

In all the above species velamen is characterised by simple pits on their walls. Such simple pits have been observed in the velamen of many terrestrial orchids by Engard (1944) and Mulay *et al.* (1956 *a*,

b, *c*), but pits in orchid velamen are more well pronounced. In epiphytic velamen so far as it has been known the thickenings are more developed than in terrestrial velamen, though essentially they are similar. Thus velamen in Liliaceæ is structurally very simple and distinct thickenings are absent in the species worked out in the present study. These thickenings resemble those of tracheids found in xylem to a marked extent and a question arises here whether these cells should be termed 'tracheids'. De Bary (1884) and Warming (1909) described velamen as a tracheidal tissue ensheathing the root. As pointed out by Dutt (1954) and Deshpande (1955) the term tracheid should be reserved to the designation of the xylem elements only.

Another feature is the occurrence of stainable granular matter. Presence of such granules has been reported by Göebel (1922) in *Aspidistra elatior* Bl. and *Anthurium ellipticum* C. Koch. *et* Bouche. Deshpande (1955 and 1956) reported the occurrence of granular matter in *Aspidistra lurida* Bak. and *Anthurium candidum* Bull. respectively.

Velamen has been variously defined by many authors. Schleiden* (1849) called it as many-layered root envelope. De Bary (1884) defined velamen as a mass of tracheids ensheathing the root. According to Göebel (1922) the term velamen means a tissue arising from the protoderm and having an exodermis as delimiting layer. He states that cells of velamen sometimes have peculiar wall thickenings, the presence of which however is not always essential. Recent textbooks on plant anatomy (Eames and Mac Daniels, 1947 and Esau, 1953) refer to velamen as 'multiseriate epidermis'. Many plants in the present investigation possess one-layered velamen. All these species possess thickenings characteristic of velamen and have algæ and fungi which is very common in all the plants examined. The presence of exodermis as a delimiting layer is also another criterion, since velamen is, as a rule, followed by a distinct exodermis. The only exceptions reported so far are to be sought in some species of *Asparagus* (Mulay and Deshpande, 1952). According to Göebel (1922) the presence of thickenings is not always an essential factor for recognising velamen in all the cases where it is bounded by distinct exodermis internally. He further says that occurrence of many-layered velamen as it is known is confined only to a few families while one-layered velamen has wider existence as it is found in many monocotyledonous families like Liliaceæ and Amaryllidaceæ. One-layered velamen has been reported by Haberlandt (1914) in *Vanilla planifolia* Andr., *Vanilla aphylla* Blume, *Dendrocolla teres* Bl., *Renanthera matutfina* Lindl. and *Trichotosia ferox* Bl. and by Mulay and Panikkar (1956) in *Microstylis rheedi* Nutt. Thus the definition of velamen as 'multiple epidermis' needs revision in the light of the facts discovered. So velamen may be defined in our opinion as an ensheathing tissue of the roots derived from protoderm by anticlinal or periclinal divisions, characterized usually by pits and thickening bands and delimited from the cortex by specialised layer 'exodermis'.

* Quoted by Engard (1944).

Summary

Velamen is the product of protoderm. Majority of the members possess one-layered velamen. In Liliaceæ velamen is structurally very simple and is characterised by pits only. Velamen is delimited from cortex by exodermis which has distinct cell wall characters and is composed of long and short cells. Complementary cells occur beneath the passage cells. Exodermis is sometimes pitted. Pads composed of granular matter occur on passage cells.

References

De Bary, A. 1884. *Comparative Anatomy of Vegetative Organs of Phanerogams and Ferns*. Oxford.

Deshpande, B. D. 1955. Velamen in roots of some species of Amaryllidaceæ. *Proc. Raj. Acad. Sci.* **5**: 41–49.

———. 1956. Velamen in terrestrial Araceæ. *Sci. & Cult.* **21**: 686–87.

Dutt, B. S. M. 1954. Some anatomical peculiarities in roots of *Crinum asiaticum* L. and *Crinum defixum* Ker. *Ibid.* **20**: 183–84.

Eames, A. J. and Mac Daniels, L. H. 1947. *An Introduction to Plant Anatomy*, 2nd ed., New York.

Engard, C. J. 1944. Morphological identity of velamen and exodermis in Orchids. *Bot. Gaz.* **105**: 457–62.

Esau, K. 1953. *Plant Anatomy*. New York.

Göebel, K. 1922. Erde wurzeln mit velamen. *Flora* **15**: 1–26.

Haberlandt, G. 1914. *Physiological Plant Anatomy*. London.

Mulay, B. N. and Deshpande, B. D. 1952. Presence of velamen in earth roots of some species of the genus *Asparagus*. *Univ Raj. Studies Biol. and Medicine* **1**: 58–73.

———, ——— and Williams, H. B. 1958. Study of velamen in some epiphytic and terrestrial orchids. *J. Indian bot. Soc.* **37**: 123–27.

——— and Panikkar, T. K. B. 1956. Origin, development and structure of velamen in roots of some species of terrestrial orchids. *Proc. Raj. Acad. Sci.* **6**: 31–48.

——— and Prasad, M. K. 1956. On the structure and development of velamen in roots of some terrestrial orchids. *Proc. Indian Sci. Congr. Agra*, Part III, p. 246.

——— and Sarin, Y. K. 1959. On the histological structure of *Satyrium nepalense* Don. and other terrestrial orchids. *Proc. Raj. Acad. Sci.* (In Press).

Warming, E. 1909. *Oecology of Plants*. London.

Explanation of Plate XI

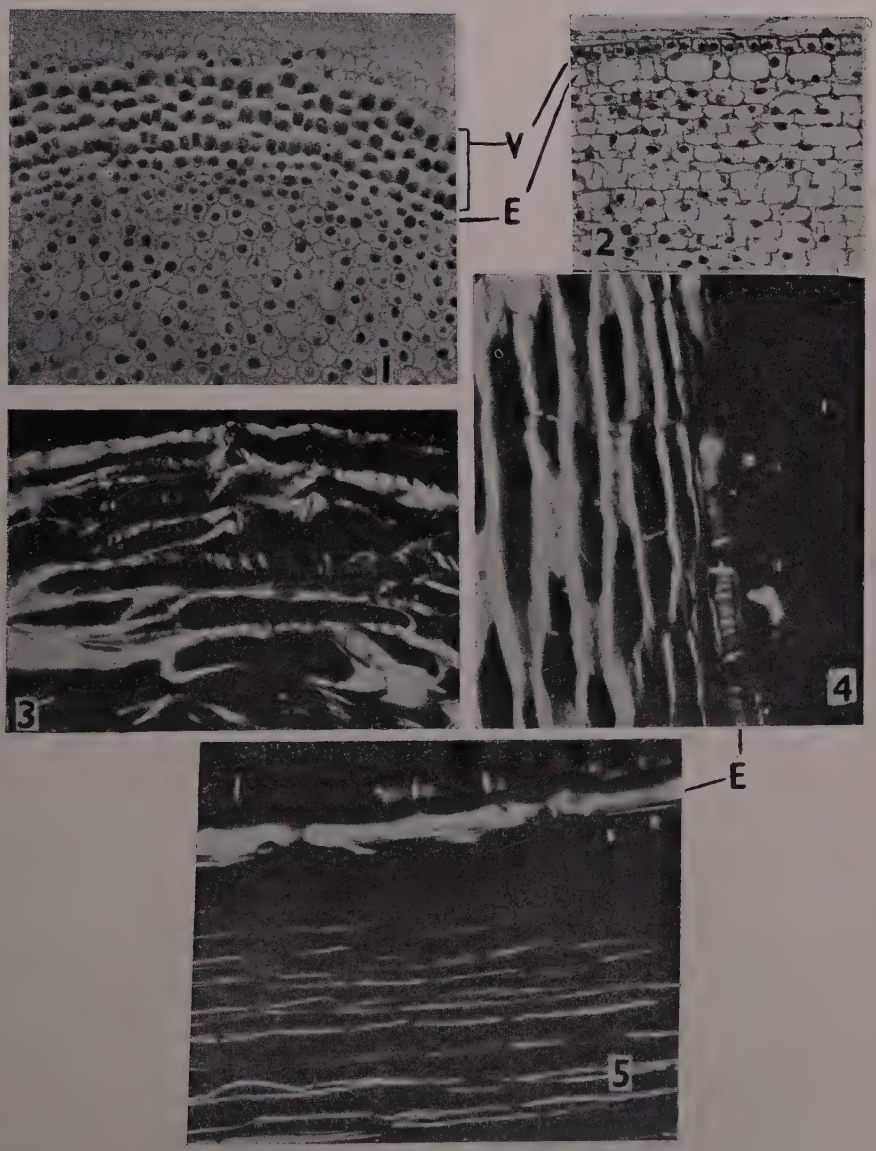
Fig. 1. Portion of root in t.s. of *Aspidistra lurida* behind the apical reigon showing four to five layers of velamen in early stages surrounded by root cap tissue, ×100.

Fig. 2. Portion of root of *Tupistra clarkei* in l.s. showing long and short cells in exodermis, ×60.

Fig. 3. Pórtion of root of *Asparagus adscendens* in l.s. under polarised light showing folds on longitudinal walls of velamen, ×100.

Fig. 4. L.s. of root of *Dracœna aungustifolia* under polarised light showing pits on exodermal walls, ×60.

Fig. 5. Portion of root of *Ruscus hypophyllum* in l.s. under polarised light showing pits on exodermal wall, ×60. V = Velamen; E = Exodermis; Ex = Exodermal cell; P = Passage cell.



B. N. Mulay and B. D. Deshpande FIGS. 1–5

A STUDY OF THE GAMETOPHYTES IN *IMPATIENS LESCHENAULTII* WALL.

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Introduction

Of the 450 species of *Impatiens* (Lawrence, 1951), the embryology of only a few species has been studied in detail. Since the publication of Schnarf's (1931) Vergleichende Embryologie der Angiospermen, wherein he summarised the embryological work done in the family, only a few more species of *Impatiens*, namely, *Impatiens roylei* (Dahlgren, 1934), *Impatiens balfourii* (Souèges, 1945) and *Impatiens glanduligera* (Steffen, 1946, 1951) have been studied. Recently the embryology of *Hydrocera triflora* (Venkateswarlu and Lakshminarayana, 1957), the only other monotypic genus of the family has been studied in detail. The important embryological features of the family are:—

The sporogenous tissue in the anther becomes divided into small groups as a result of trabeculate partitions arising from the tapetum. The divisions in the pollen mother cells are simultaneous. Ripe pollen is 2-nucleate.

The ovule in the family is tenuinucellate and bitegmic. The innermost layer of the inner integument forms the endothelium. The primary archesporial cell which is hypodermal directly acts as the megaspore mother cell. No parietal tissue is present. Within the same genus *Impatiens*, monosporic as well as bisporic types of embryo-sac development occur. The antipodals degenerate very early.

Fertilisation is porogamous.

The endosperm development is of the cellular type. Chalazal and micropylar endosperm haustoria are present. Of these the latter are aggressive and branched reaching the placental tissue.

The embryo development in *Impatiens balfourii* (Souèges, 1945), *Impatiens glanduligera* (Steffen, 1946) and *Hydrocera triflora* (Venkateswarlu and Lakshminarayana, 1957) follows the Asterad type. In *Impatiens balfourii* (Souèges, 1945) and *Hydrogera triflora* (Venkateswarlu and Lakshminarayana, 1957) it conforms to the Geum variation while in *Impatiens glanduligera* (Steffen, 1946) it conforms to Senecio variation.

This paper deals with the study of the male and female gametophytes in *Impatiens leschenaultii*.

Materials and Methods

The material was collected by the senior author from plants growing wild at Ooty and was fixed in F.A.A. and also in acetic alcohol. The material fixed in acetic alcohol proved better. Usual methods of dehydration, infiltration and embedding were followed. Sections were cut at a thickness of 4–12 microns and were stained in Crystal violet using Erythrosine as counterstain.

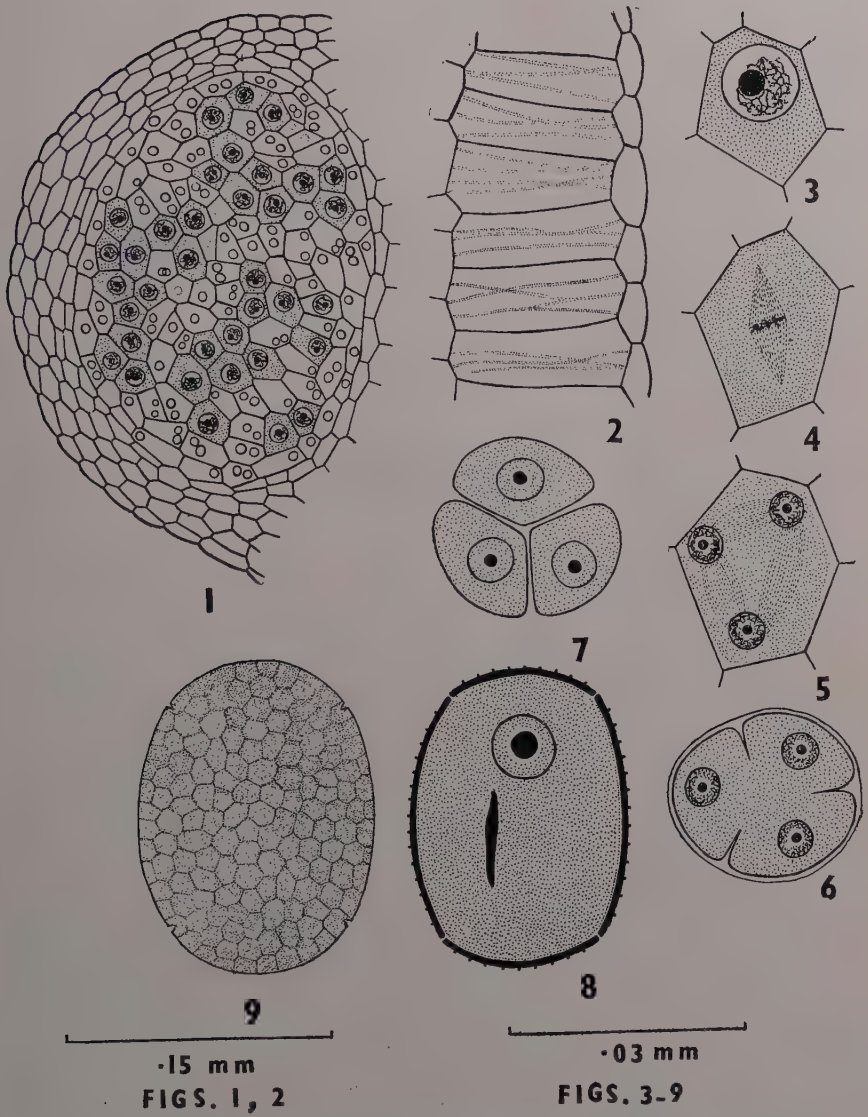
Microsporogenesis and Male Gametophyte

The flower possesses five stamens which form a hood on the pistil. A fully developed anther in *Impatiens leschenaultii* shows an epidermis and four wall layers (Text-Fig. 1). The cells of the hypodermal wall layer develop fibrous thickenings and form an endothecium in the mature anther (Text-Fig. 2), while the middle layers get crushed during the development of the anther. The sporogenous tissue is divided into small groups by trabeculate partitions (Text-Fig. 1). These partitions arise from the anther tapetum which surrounds the sporogenous tissue in early stages. The cell of the tapetum as well as the cell forming the trabeculæ become 2-nucleate by the time the pollen mother cells begin to undergo meiosis (Text-Fig. 1). The identity of the tapetal cells as well as the cells forming the trabeculæ is not lost, although their contents become absorbed. The remnants of these can be seen even at the stage of the formation of pollen tetrads. By the time the pollen grains become fully developed they become completely absorbed.

Meiosis in the pollen mother cells presents no unusual features (Text-Figs. 3–6). Cytokinesis takes place by furrowing (Text-Fig. 6). Pollen tetrads show tetrahedral arrangement (Text-Fig. 7). Pollen grains are 2-celled at the time of shedding (Text-Fig. 8). The generative nucleus is seen as an elongated structure. The pollen grains in a cross-section present a more or less rectangular appearance. The exine shows four germinal furrows and the surface presents a reticulate appearance (Text-Fig. 9) and the rims of the ridges of the meshes appear as small projections in the cross-sections of the pollen grains.

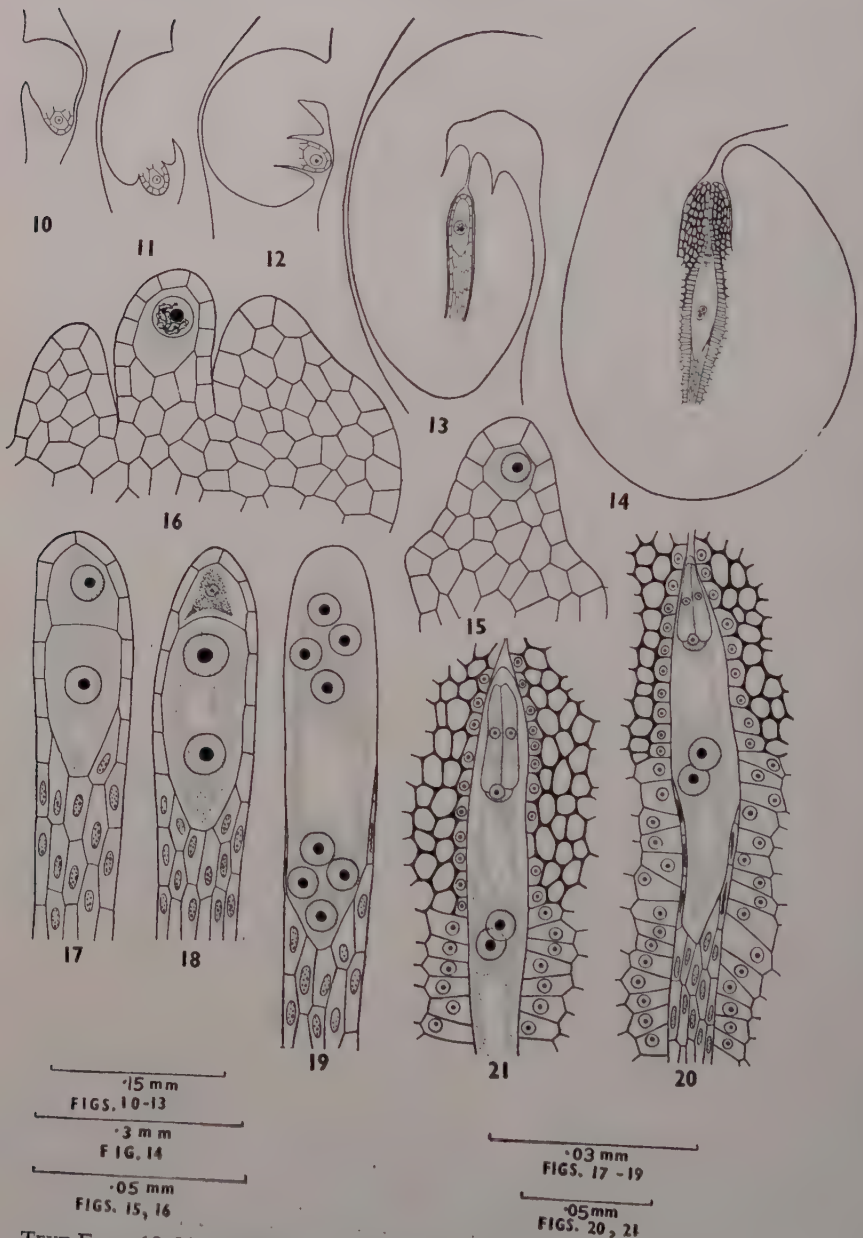
Ovary and Ovule

The ovary is 5-carpellary, syncarpous with 2–3 ovules in each loculus. The ovule is bitegmic, anatropous and tenuinucellate (Text-Figs. 13 and 14). The ovule primordium arises as a curving outgrowth from the placenta. By the time the archesporium is differentiated in the ovule primordium the integumentary primordia are also laid down. During development the ovule undergoes a curvature and becomes anatropous with the micropyle pointing upwards (Text-Figs. 10–14). The integuments are fused throughout except at the top where they are free from each other for a short distance (Text-Figs. 13 and 14). The micropyle is formed by the inner integument alone (Text-Figs. 13 and 14). The innermost layer of the inner integument forms the endothelium (Text-Figs. 14, 20 and 21). The cells of the endothelium are



TEXT-FIGS. 1–9. Fig. 1. T.S. antherlobe showing epidermis, wall layers and the sporogenous tissue which is divided into groups by sterile cell partition. Fig. 2. Fibrous endothecium. Figs. 3–6. Stages in meiosis in the pollen mother cells. Fig. 7. Pollen tetrad. Fig. 8. Section of the pollen grain showing the vegetative and generative nuclei. Fig. 9. Surface view of the pollen grain.

thin-walled in the lower half, while in the upper half they are thick-walled (Text-Figs. 14, 20 and 21). Some of the cells of the inner integument lying next to the thick-walled cells of the endothelium also show



TEXT-FIGS. 10–21. Figs. 10–13. Stages in the development of the ovule. Fig. 14. L.S. mature ovule showing the embryo-sac, the integuments and the endothelium. Fig. 15. L.S. ovule showing the primary archesporium. Fig. 16. L.S. ovule showing megaspore mother cell. Fig. 17. L.S. ovule showing the dyad cells. Upper dyad cell smaller in size. Integuments not represented.

Fig. 18. L.S. ovule showing the 2-nucleate embryo sac. Integuments not shown. Fig 19. L.S. ovule showing the 8-nucleate embryo-sac. Integuments not shown. Fig. 20. L.S. ovule showing the young enlarging embryo-sac. Fig. 21. L.S. ovule showing the micropylar part of the embryo-sac. Note the thick-walled cells of the endothelium.

thick walls. The inner integument at the micropylar region shows a characteristic structure. The outer walls of the epidermis in this region are thin while the radial and inner tangential walls as well as the walls of the cells in the middle are greatly thickened (Text-Fig. 14). These thick-walled cells extend downwards and merge with the thick-walled cells of the endothelium. Parietal tissue is completely absent.

Megasporogenesis and Female Gametophyte

The primary archesporium in the ovule consists of a single hypodermal cell (Text-Fig. 15) which directly becomes the megaspore mother cell without cutting off a parietal cell (Text-Fig. 16), as in the other investigated species of *Impatiens* (Ottley, 1918; Dahlgren, 1934) and *Hydrocera* (Venkateswarlu and Lakshminarayana, 1957). The nucellar epidermis surrounds the megaspore mother cell on the sides and above while on the lower side is a narrow strand of elongated cells of the nucellus (Text-Fig. 13). The nuclei of these cells are elongated and in them are seen several deeply staining chromatic bodies. Most of this tissue remains intact till the 8-nucleate stage of the embryo-sac, although some of the cells become crushed. The megaspore mother cell divides resulting in the formation of the dyad cells of which the upper is smaller in size (Text-Fig. 17). This dyad cell degenerates soon (Text-Fig. 18). The lower dyad cell by three successive free nuclear divisions gives rise to the 8-nucleate embryo-sac (Text-Fig. 19). Thus, the embryo-sac development in *Impatiens leschenaultii* follows the Allium type (see Maheshwari, 1950) as in *Impatiens sultani* (Ottley, 1918), *Impatiens roylei* (Dahlgren, 1934) and *Hydrocera triflora* (Venkateswarlu and Lakshminarayana, 1957). The egg apparatus consists of two synergids which are elongated with basal vacuoles and an egg which extends slightly beyond the synergids (Text-Figs. 20 and 21). The antipodals are ephemeral (Text-Fig. 20). The polar nuclei fuse in the middle and the secondary nucleus lies not far from the egg apparatus.

The embryo-sac enlarges during development crushing the narrow strand of nucellar cells lying below and the mature embryo-sac directly borders on the innermost layer of the inner integument (Text-Figs. 14, 20 and 21).

Discussion

The behaviour of the anther tapetum in *Impatiens leschenaultii* is interesting. The sporogenous tissue in early stages is surrounded by a tapetal layer, the cells of which soon protrude into the sporogenous tissue dividing it into small groups. In *Impatiens sultani* (Ottley, 1918) and *Hydrocera triflora* (Venkateswarlu and Lakshminarayana, 1957)

a similar situation has been reported. While the tapetal cells and the cells forming the trabeculæ in *Impatiens leschenaultii* and *Hydrocera* (Venkateswarlu and Lakshminarayana, 1957) are parietal in origin, Ottley (1918) holds that the cells of the tapetum and also the cells forming the trabeculæ in *Impatiens sultani* arise as a result of sterilisation of the sporogenous tissue. Divisions in the pollen mother cells in *Impatiens leschenaultii* as in the investigated species of *Impatiens* are simultaneous. The pollen grains are 4-colpate although Ottley (1918) reported 4-germ pores in *Impatiens sultani*. In *Hydrocera* (Venkateswarlu and Lakshminarayana, 1957) however, the pollen grains are 3-colpate.

The ovule in *Impatiens leschenaultii* is tenuinucellate, bitegmic and anatropous as in other species of *Impatiens* (Schnarf, 1931 and Dahlgren, 1934) and *Hydrocera triflora* (Venkateswarlu and Lakshminarayana, 1957). No parietal cells are cut off as in *Impatiens sultani* (Ottley, 1918), *Impatiens roylei* (Dahlgren, 1934) and *Hydrocera triflora* (Venkateswarlu and Lakshminarayana, 1957). Raitt (1916) working on *Impatiens pallida* reported the occurrence of a parietal cell. Her illustrations, however, are inconclusive, an opinion also held by Ottley (1918). The integuments in the family show varying degrees of fusion. In *Impatiens pallida* (Raitt, 1916) and *Impatiens parviflora* (Guignard, 1893) they are distinct throughout. But according to Brandza (1891) there is only one integument in *Impatiens balsamina*. Probably here the fusion extends throughout. Brunotte (1900), however, states that there are two integuments in the family. In *Impatiens leschenaultii* as in *Impatiens sultani* (Ottley, 1918), *Impatiens roylei* (Dahlgren, 1934) and *Hydrocera triflora* (Venkateswarlu and Lakshminarayana, 1957) the integuments are fused throughout except at the top where they are free for a short distance.

Both normal and bisporic types of embryo-sac development occur in the family. In *Impatiens balsamina* and *Impatiens fulva* (Schnarf, 1931) the development follows the normal type. In *Impatiens leschenaultii*, however, it follows the Allium type (Maheshwari, 1950), as in *Impatiens sultani* (Ottley, 1918), *Impatiens roylei* (Dahlgren, 1934) and *Hydrocera triflora* (Venkateswarlu and Lakshminarayana, 1957).

Summary

The development of the male and female gametophytes in *Impatiens leschenaultii* has been studied.

The anther structure shows an epidermis and four wall layers of which the hypodermal layer develops into the fibrous endothecium in the mature anther. The sporogenous tissue is divided into groups by sterile cell partitions. Divisions in the pollen mother cells are simultaneous. Pollen grains are 4-colpate and are 2-celled at the shedding stage.

The ovules are tenuinucellate, bitegmic and anatropous. Parietal tissue is absent. The innermost layer of the inner integument forms the endothelium.

The embryo-sac develops according to the Allium type. The mature embryo-sac directly borders the endothelium. The antipodals are ephemeral.

References

*Brandza, M. 1891. Development des teguments de la graine. *Rev. gen. Bot. Paris.* **1**: 1–32, 71–84, 103–26, 150–65, 227–40.

Dahlgren, K. V. O. 1934. Die Embryologie von *Impatiens roylei. Svensk bot. Tidskr.* **28**: 103–25.

*Guignard, L. 1893. Recherches sur le dévelopment de la graine et en particulier du tégument séminal. *J. Bot. Paris.* **7**: 1–14, 21–34, 57–66, 97–106, 140–53, 205–14, 241–50, 282–96, 303–11.

Lawrence, G. H. M. 1951. *Taxonomy of Vascular Plants*, New York.

Maheshwari, P. 1950. *An Introduction to the Embryology of Angiosperms.* McGraw-Hill Co.

Ottley, A. M. 1918. A contribution to the life-history of *Impatiens sultani*, *Bot. Gaz.* **66**: 289–317.

*Raitt, A. H. 1916. Development of ovule of *Impatiens Pallida* Nutt. *Plant World.* **19**: 195–203.

Schnarf, K. 1931. *Vergleichende Embryologie der Angiospermen.* Berlin.

Souèges, R. 1945. Embryogénie des Balsaminacées. Dévelopment de l'embryon chez l'*Impatiens balfourii* Hook. *C.R. Acad. Sci., Paris.* **220**: 837–40.

Steffen, K. 1946. Bemerkungen zur Polarität der Angiospermeneizelle. *Z. Natur. forsch.* **1**: 331–36.

————. 1951. Zur Kenntnis Betruchtungs vorganges bei *Impatiens glanduligera* Lindl. Cytologische Studien am Embryosack der Balsamineen. *Planta* 39: 175–244.

Venkateswarlu, J. and Lakshminarayana, L. 1957. A contribution to the embryology of *Hydrocera triflora* W & A. *Phytomorphology* **7**: 191–203.

*Originals not seen.

A NOTE ON SPECIES OF *STICHOCOCCUS* AND *HORMIDIUM* FROM DELHI

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(Received for publication on February 19, 1959)

The object of this note is to record a species of the genus *Stichococcus* and of *Hormidium* from Delhi. Fritsch recognises *Stichococcus* as a member of family *Ulotrichaceæ* of the order Ulotrichales. The species described below appear on flower-pots in the cold months of November and December in the form of dark-green covering, and disappear in the month of March. They have a pronounced preference for baked clay.

1. *Stichococcus bacillaris* Naeg. (Text-Fig. 1)

The filaments are composed of a few cylindrical cells, which readily dissociate into individual cells. Each cell has a parietal plate like

1

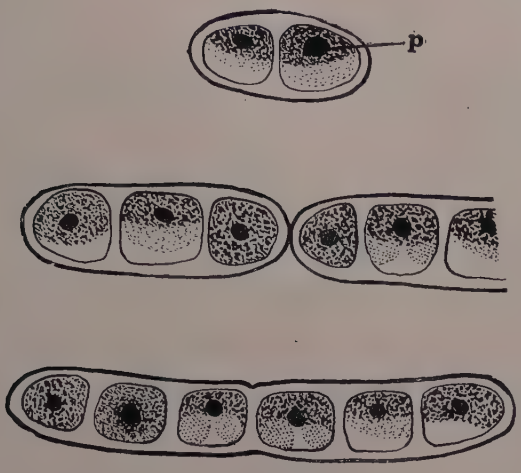
Text-Fig. 1. *Stichococcus bacillaris* Naeg. showing a filament, a loose cell and fragmentation × 1,600.

chloroplast, occupying only a portion of the cell, and devoid of a pyrenoid. The cells are 1·9–3·8 μ broad and 3·8–5·7 μ long.

Habitat.—On the sides of the flower-pots in New Delhi.

2. *Hormidium flaccidum* Kütz. (Text-Fig. 2)

Filaments with a few cylindrical cells which readily break up into individual cells. Cells, 5·7–7·6 μ broad, 3·8–11·4 μ long. Chloroplast a flattened parietal plate, occupying most of the cell and sometimes with one fold with a single prominent pyrenoid in each cell. Reproduction is by fragmentation.



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TEXT-FIG. 2. *Hormidium flaccidum* Kütz., showing a dividing cell and two filaments. Mark the pyrenoid (*p*) in the chloroplasts, × 1,180.

Habitat.—On the sides of the flower-pots along with *Stichococcus bacillaris* in New Delhi.

REFERENCES

FRITSCH, F. E. 1935. *The Structure and Reproduction of the Algæ*, Vol. I. Cambridge.

HEERING, W. 1914. *Ulotrichales, Microsporales, Oedogoniales:* in Pascher's *Süsswasser-flora, Österreichs und der Schweiz*, **6**; *Chlorophyceæ* **3**, Jena.

SMITH, G. M. 1933, 1950. *The Freshwater Algæ of the United States*, New York.

CYTOMORPHOLOGICAL STUDIES OF *OLIGOTRICHUM* LAM. *ET* DE CAND.

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It was felt that cytomorphological studies of mosses would throw some light on the evolution in the group. A start was made with *Pogonatum* Palis of the family Polytrichaceæ. The results were encouraging, so *Oligotrichum semilamellatum* (Hook.) Mitt., another member of the same family, was selected for study.

The material was collected from Darjeeling (Eastern Himalayas, 6,000–7,000 feet height), fixed in formalin-acetic-alcohol and later preserved in 50% alcohol. The studies were made by paraffin infiltration and microtome sectioning. The sections were cut 6–10 μ thick and stained with safranin fast-green stains. Knop's solution was used for germination of spores and the protonema was later transferred to sterilised soil where the buds developed. Acetocarmine squashes of the dividing spore mother cells were prepared after fixing the capsules in 1 : 3 acetic alcohol.

Observations

The smooth spherical spores have a third hyaline layer the perinium or epispore (Text-Fig. 1). The structure and the germination of spores are very similar to those of *Pogonatum* (Chopra and Sharma, 1958). The branching of the protonema shows the same pattern as described by Allsopp and Mitra (1956). There are a few broader, brown, 'stolon-like' filaments, from which arise green, epigeal branches with numerous chloroplasts and comparatively narrower, hypogeal branches—the rhizoids. Allsopp and Mitra noted that the buds generally arise from the bases of green erect branches. In this species, however, the buds generally arise from the brown stolon-like branches, though sometimes they are formed on the green branches too and all the types of branches form a prostrate system.

The brown branches are differentiated late in the development of the protonema and are mere transformations of green filaments because towards their tips they are themselves green and also bear several green branches at intervals. It appears that brown filaments are meant for perennation during temporary microdrought conditions.

Narayanaswami and Lal (1957) also observed such branches but it is not felt necessary to maintain such expressions as rhizo-nemata or rhizo-protonemata (Narayanaswami, 1957).

The buds generally arise on the sides of filaments a little below the septa but sometimes it may be terminal on a branch (Text-Fig. 2). Goebel (1905) has already recorded certain cases where protonemata thread directly passes into a shoot and it will be discussed at a later stage. In the club-shaped bud initial a four-sided apical cell is formed by three oblique intersecting walls either immediately or in the upper cell after one transverse division (Text-Fig. 3). The three peripheral cells and a few early segments of the apical cell form first simple leaves to protect the growing tip as indicated by Campbell (1895). The development of these leaves could not be made out in *Pogonatum*. Each peripheral cell divides transversely into two cells (Text-Fig. 3), the upper of which is the initial (Text-Fig. 2) of a simple leaf which is nothing more than a plate of cells. The stem structure of young culture plants is also very simple and the normal leaves start their appearance after a considerable growth of the stem. The rhizoids on the new plants may develop very early or sufficiently late and some of them turn green and mix with the protonema.

Growth of the Gametophyte

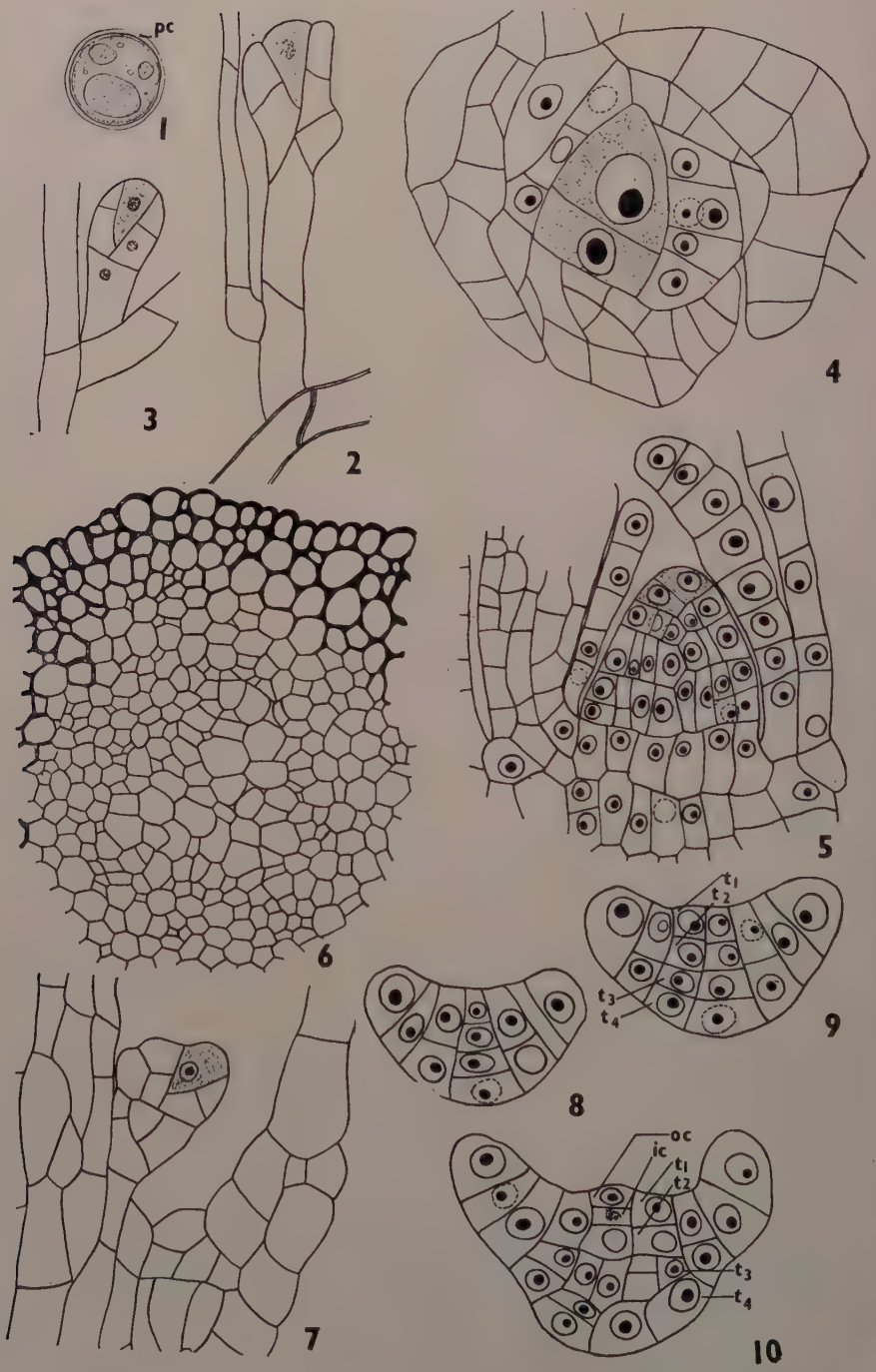
The stem grows by means of an apical cell and its segmentation and further development is exactly in the same manner as in *Pogonatum*. Out of 50–60 vegetative and male plant tips studied, in two male plants an abnormality was noted. In these cases the apical cell cuts off segments parallel to the flat surfaces (Text-Fig. 4) reminding one of the manner of division in leafy liverworts. This point is being persued further. Normally a segment divides vertically into an inner and an outer cell (Text-Fig. 5) and the latter after some time is divided by a horizontal wall to form the upper and the lower cell. Although initiation of the leaf could not be made out, yet there is reason to believe (Text-Fig. 5) that it develops from the upper cell.

A transverse section of the mature stem (Text-Fig. 6) can be readily distinguished from that of *Pogonatum microstomum* due to the absence of thick-walled cells of the conducting strand, but is very similar to that of *P. stevensii* and *P. perichætiale*.

Normally the plants are unbranched but sometimes young branches on the stem have been observed. A branch also grows by a four-sided apical cell (Text-Fig. 7).

The Leaf

Broadly speaking the development of the leaf follows the same pattern as in *Pogonatum*; the details, however, are different. At a young stage one or two median cells (as seen in cross-sections) undergo horizontal divisions, *i.e.*, parallel to the leaf surface. Each of these



TEXT-FIGS. 1–10

TEXT-FIGS. 1–10. Fig. 1. *pc*, perinium. A spore, ×900. Figs. 2, 3. Buds on the protonema (whole mount), ×400. Fig. 4. C.s. through male plant tip showing abnormal segmentation of the apical cell, ×900. Fig. 5. L.s. growing plant tip, ×600. Fig. 6. A portion of the T.s. of the mature stem, ×270. Fig. 7. A part of the L.s. of the plant passing through a lateral branch, ×400. Figs. 8–10. *ic*, inner cell; *oc*, outer cell; *t*, tier of cells. Cross-sections of the young developing leaves at various stages of development, ×900.

cells divides again in the same manner (Text-Fig. 8). One cell on either side of these follows suit (Text-Fig. 9). Thus four layers or tiers of cells are produced (Text-Fig. 9, t_1–t_4). Divisions in the lowermost tier (t_4) are rather rare and this layer produces the lower epidermis. Cells of the layer next above it, *i.e.*, t_3 divide and subdivide in various planes (Text-Figs. 10, 11) to produce a tissue which is ultimately differentiated into the lower sclerenchyma (Text-Fig. 12, *lsc*) and the 'phloem-like' cells or begleiter cells. Cells of the second layer from the top, *i.e.*, t_2 do not divide at all and form a row of large prominent cells from one to the other side of the midrib (Text-Figs. 11, 12). These cells in the mature leaf are the 'xylem-like' cells or the deuter cells. Cells of the uppermost layer (t_1) divide into outer and inner cells (Text-Fig. 10, *oc*, *ic*). The inner cells divide and redivide to produce a group of cells above the row of prominent cell (Text-Fig. 11). These mature into upper sclerenchyma (Text-Fig. 12, *usc*). Outer cells function as lamellæ initials (Text-Fig. 11) and produce lamellæ by repeated transverse divisions (Text-Figs. 11, 12). Ultimately these cells at the bases of the lamellæ form the upper epidermis. A few more lamellæ are added on the upper surface by the divisions of the cells on the sides of the midrib which expands. Near the tip of the leaf one or two rudimentary lamellæ, 1–3 cells high, are developed on the back side also from the cells of the lower epidermis (Text-Fig. 12).

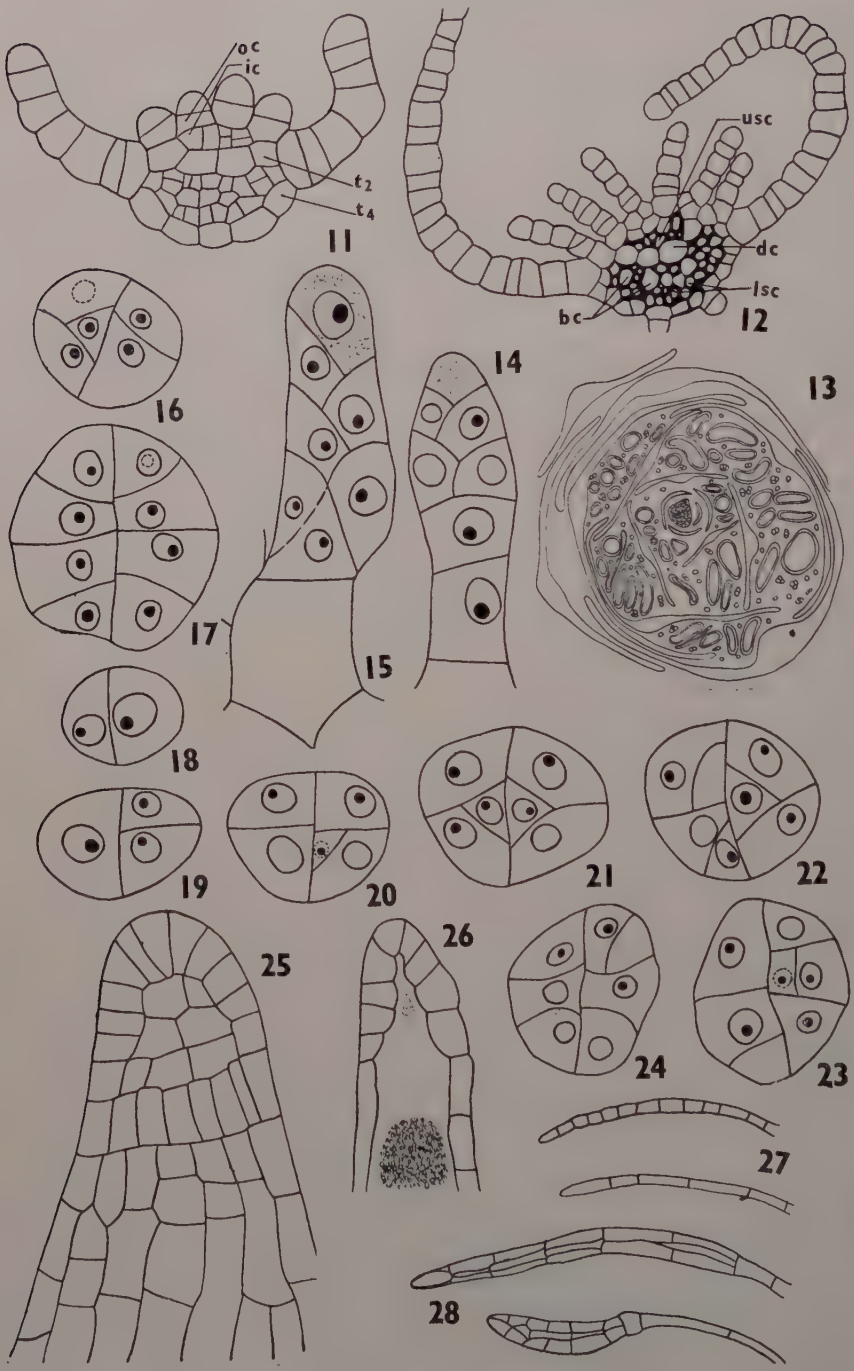
Hairs are associated with the young leaves (Text-Fig. 5). The development of these hairs has not been studied.

A mature leaf has got a narrow midrib, with one cell thick, broad wing on either side. The midrib bears 6–9 plates of cells standing side by side—the lamellæ—appearing like uniseriate filaments in cross-sections (Text-Fig. 12) on its upper surface and one or two rudimentary lamellæ on the lower surface near the tip. The upper lamellæ are 4–6 cells high and all the cells are alike while the lower ones are 1–3 cells high. The midrib is composed of thick-walled sclerenchyma, the 'xylem-like' cells or the deuter cells and the 'phloem-like' or the beglieter cells as described by Brotherus *et al.* (1924) (Text-Fig. 12, *bc*, *dc*).

SEX ORGANS

The plants are strictly diœcious and the male ones which form a cup-shaped head are smaller than the female plants.

The plants are anacroanderous and the antheridia are borne in the axils of the perigonial leaves (Text-Fig. 13). Each antheridial



TEXT-FIGS. 11–28

TEXT-FIGS. 11–28. Fig. 11. *ic*, inner cell; *oc*, outer cell; *t*, tier. C.s. developing leaf, ×600. Fig. 12. *bc*, begleiter cells; *dc*, deuter cells; *lsc*, lower sclerenchyma; *usc*, upper sclerenchyma. *T.s.* mature leaf, ×270. Fig. 13. T.s. through male head showing axillary position of antheridia, ×60. Figs. 14, 15. L.s. young antheridia with apical cell and a few segments, ×900. Fig. 16. T.s. developing antheridium showing normal division of the segments, ×900. Fig. 17. Tip segments of antheridium showing abnormal divisions, ×900. Figs. 18–24. Serial T.s.s of young antheridium showing normal divisions of two middle tiers of segments (section 21 is seen twice) and abnormal in the tip and the base segments, ×900. Fig. 25. Tip of the mature antheridium (whole mount), ×400. Fig. 26. L.s. tip of the mature antheridium showing short canal-like cavity, ×270. Figs. 27, 28. Two types of paraphyses among antheridia (whole mount), ×100.

initial divides by one or two transverse walls and in the terminal cell an apical cell with two cutting faces is established which cuts off two series of segments (Text-Figs. 14, 15).

Most of the segments formed by the apical cell excepting a few at the top and the base, divide by two vertical intersecting walls to form androgonial and wall cells (Text-Fig. 16) as in *Funaria* (Campbell, 1895), *Pogonatum microstomum* (Chopra and Sharma, 1958) and *Barbula indica* (Bannerji and Subirsen, 1956). Some segments near the tip and the base of the antheridium show different types of variations with regard to their divisions.

A tip segment may divide by a median vertical wall into two cells which again divide by oblique vertical walls into larger and smaller cells (Text-Fig. 17). Sometimes a segment divides by a median vertical wall and in the resultant cells periclinal walls are laid to form inner and outer cells (Text-Fig. 20). This resembles the development of androgonial cells at the corresponding stages in Anthocerotales, Marchantiales and Acrogyneæ.

Another type of variation, generally at the base, is that a segment first divides by two parallel vertical walls into three cells and the middle one then divides into an inner and an outer cell (Text-Fig. 23). This is similar to the formation of androgonial and wall cells described in *Pogonatum stevensii* (Chopra and Sharma, 1958) and to the divisions of the segments of the archegonial pedicel in the present species and in *Atrichum* (Chopra and Bhandari—in press).

Generally several segments in the middle divide normally but serial sections of one young antheridium (Text-Figs. 18–24) indicate that sometimes only two middle tiers divide in normal fashion and rest in various other ways.

The tip of the mature antheridium (Text-Fig. 25) is distinct and is bounded by more or less isodiametric cells enclosing a short canal-like cavity (Text-Fig. 26). Possibly when the mouth of the antheridum opens, the sperms are ejected out through this canal with some force.

The androgonial cells divide many times to form blocks of cells and finally the spermacytes round off and lie free in the cavity of the antheridium. Each spermacyte develops a thin-coiled sperm. At no

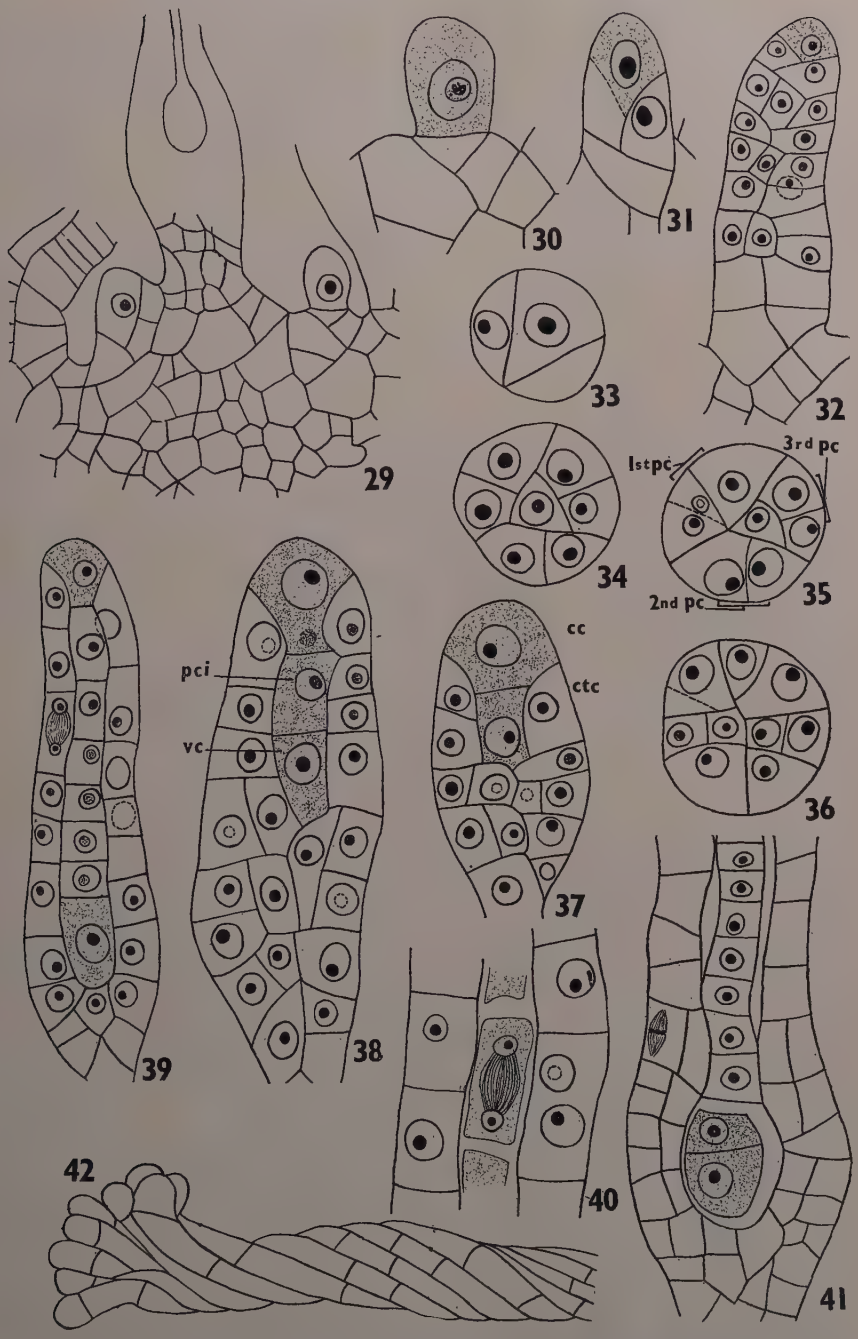
stage in the development of the androgonial cells free nuclear divisions are observed which have been described in *Barbula indica* by Bannerji and Subirsen (1956).

Two types of paraphyses are seen intermixed with antheridia. One type is of simple long uniseriate filaments (Text-Fig. 27) and in the other type a paraphysis has a long uniseriate stalk with a multiseriate head (Text-Fig. 28). Further observations are being made to determine the segmentation of the paraphyses of the second type.

The female plants are acrogynous, fewer archegonia are developed in a single head and there is reason to believe that the first archegonium is formed from the apical cell itself as the most mature archegonium is always in the centre (Text-Fig. 29). The secondary archegonia are developed from the segments below the apical cell.

In Polytrichideæ and Bryideæ three types of archegonium developments are recognised—(I) *Funaria* type by Campbell (1895), (II) *Mnium cuspidatum* by Holferty (1904) or *Atrichum angustatum* type by Bryan (1917), and (III) *Mnium undulatum* type by Goebel (1905). In this species second type of development is observed.

An archegonial initial projects above its surroundings (Text-Fig. 30) and later divides by a transverse wall into an upper and a lower cell. In the former a three-sided apical cell is established by two oblique intersecting walls (Text-Fig. 31). This apical cell forms 6–7 tiers of segments by its two cutting faces (Text-Fig. 32) which divide further to form the stalk or the pedicel of the archegonium. The divisions in these segments (Text-Fig. 36) resemble those in the antheridial segments of *Pogonatum stevensii* and abnormal division of antheridial segments of *Oligotrichum semilamellatum* (Text-Figs. 23, 24). Generally after cutting off 2–3 tiers of segments the three-sided apical cell is transformed into a four-sided one. Text-Figures 33–36 are the serial sections of a young archegonium where the apical cell has just become four-sided. During transformation one of the segments is smaller than usual and forms one of the three peripheral cells (Text-Fig. 35, 1st, *pc*). Two intersecting walls are laid in the ultimate segment resulting into two more peripheral cells (Text-Fig. 35, 2nd and 3rd *pc*) and a primary axial cell in the centre. Each of the three peripheral cells divides by a radial vertical wall forming six cells which by further divisions form the ventre. The primary axial cell, truncate below, divides by a transverse wall into outer cover cell (Text-Fig. 37, *cc*) and inner central cell (Text-Fig. 37, *ctc*). The central cell divides further by another transverse wall forming a lower ventral cell (*vc*) and the upper primary canal initial (*pci*) (Text-Fig. 38). Hereafter the cover cell functions as an apical cell and produces four series of segments, three peripheral and one median. Each peripheral cell divides into two by a vertical wall so as to produce six rows of cells. Those of the median series form the neck canal cells. Although many dividing figures have not been seen, yet from the size of the cells, the granular nature of the chromatin in the nuclei and due to some division figures, it is reasonable to believe



TEXT-FIGS. 29–42. Fig. 29. L.s. through female head showing mature archegonium in the Centre, ×400. Fig. 30. Initial of the archegonium (l.s.), ×900.

Fig. 31. Formation of the apical cell of the archegonium with two cutting faces (L.s.), ×900. Fig. 32. Two series of segments which form the pedicel of the archegonium. ×600. Figs. 33–36. *pc*, peripheral cell. Serial T.s.s of a young archegonium, showing transformation of 3-sided apical cell to 4-sided one. ×900. Figs. 37–41. *cc*, cover cell; *ctc*, central cell; *pci*, primary canal initial; *vc*, ventral cell. Longitudinal sections of the archegonia showing various stages of development. Figs. 37, 38, 40. ×900; Figs. 39, 41, ×600. Fig. 42. Whole mount of the top portion of the neck showing its torsion and opening of the mount, ×270.

that the intercalary divisions of the original neck cells, neck canal cells and the primary neck initial do take place (Text-Figs. 39, 40). In Text-Fig. 39 we find that the segment below the apical cell is larger than others below it. Perhaps a case like this may have lead Goebel to describe the III type of archegonial development. Further attempts are being made to clarify this point.

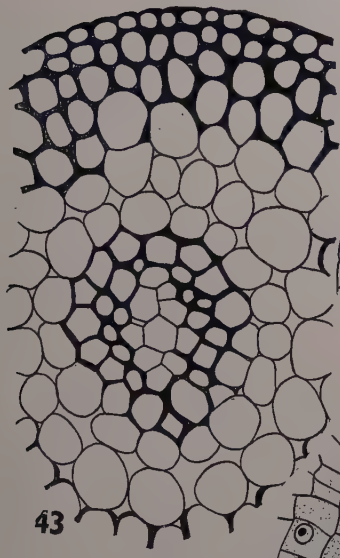
When the archegonium is about to mature the ventral cell divides by a transverse wall to form the egg and the ventral canal cell (Text-Fig. 41). Text-Figure 42 clearly indicates that the apical cell cuts off the peripheral cells in the same manner as that in the stem and consequently the rows of neck cells are spirally twisted as also pointed out by Holferty (1904).

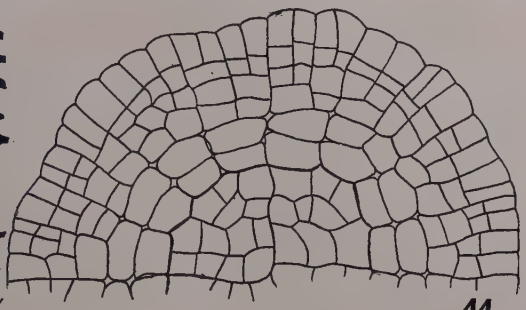
As in *Pogonatum* the ventre becomes several layers of cells in thickness and the same is true of neck at its base when the archegonium is fully mature. The neck at its tip opens by splitting apart of the different rows of cells forming a funnel-shaped mouth (Text-Fig. 42). The egg rounds off, the neck canal cells and the ventral canal cell disorganise and after fertilisation the egg turns into a zygote.

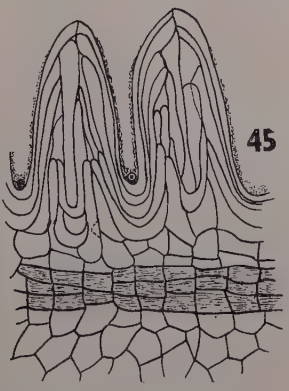
Sporophyte

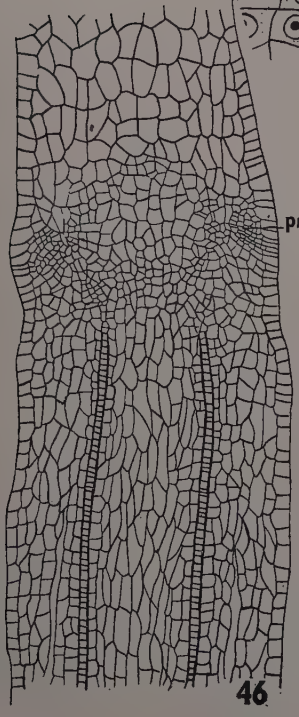
The development of the embryo and formation of foot, seta and capsule is exactly on the same lines as in *Pogonatum* and is similar to that described by earlier authors (Campbell, 1895; Vaizy, 1888). Internally the seta has got a comparatively better organization and a transverse section of the mature portion (Text-Fig. 43) shows an epidermal layer, a broad cortex and a central strand. The epidermis and the cortex are formed by the amphithecium. Its two innermost layers of 16 cells each develop intercellular spaces at an early stage of organization (Text-Fig. 44) and later form the inner cortex of loosely packed cells (Text-Fig. 43). The outer layers of amphithecium give rise to the outer cortex, the cell-walls of which become gradually thickened with the age of the seta. The central strand is the result of the endothecium and is composed of outer two to three layers of thick-walled scleren chymatous cells and a few thin-walled cells in the centre.

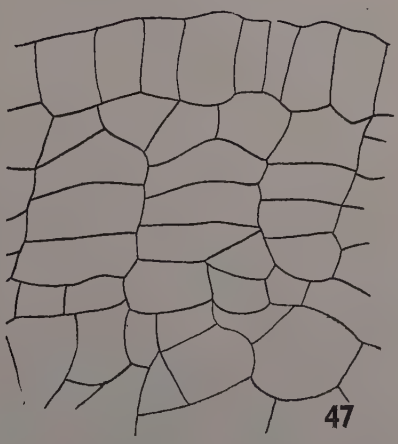
Capsule has got both inner and outer air-spaces and the archesporium is formed from the outermost layer of endothecium. Immediately below the capsule the seta does not possess any intercellular spaces and is a solid structure. It cannot be said that the spaces here are yet to be developed because during the organization of the lower seta, these make their appearance very early (Text-Fig. 44). It appears











TEXT-FIGS. 43–48

TEXT-FIGS. 43–48. Fig. 3. A portion of the T.s. of mature seta, ×400. Fig. 44. A portion of the T.s. of sporophyte where organisation into different parts of seta has just started, ×600. Fig. 45. Two adjacent peristome teeth (whole mount) showing various parts, ×135. Fig. 46. *pr*, peristone region, L.s. developing capsule showing different regions, ×135. Fig. 47. A portion of the T.s. capsule through peristome region showing three sectors, ×600. Fig. 48. A part of the L.s. capsule (peristome region), ×600.

that there is no communication between the intercellular spaces of seta and the air-spaces of capsule. The capsule possesses a small apophysis and its wall has got several stomata. The epidermal cells of capsule are not papillate.

PERISTOME

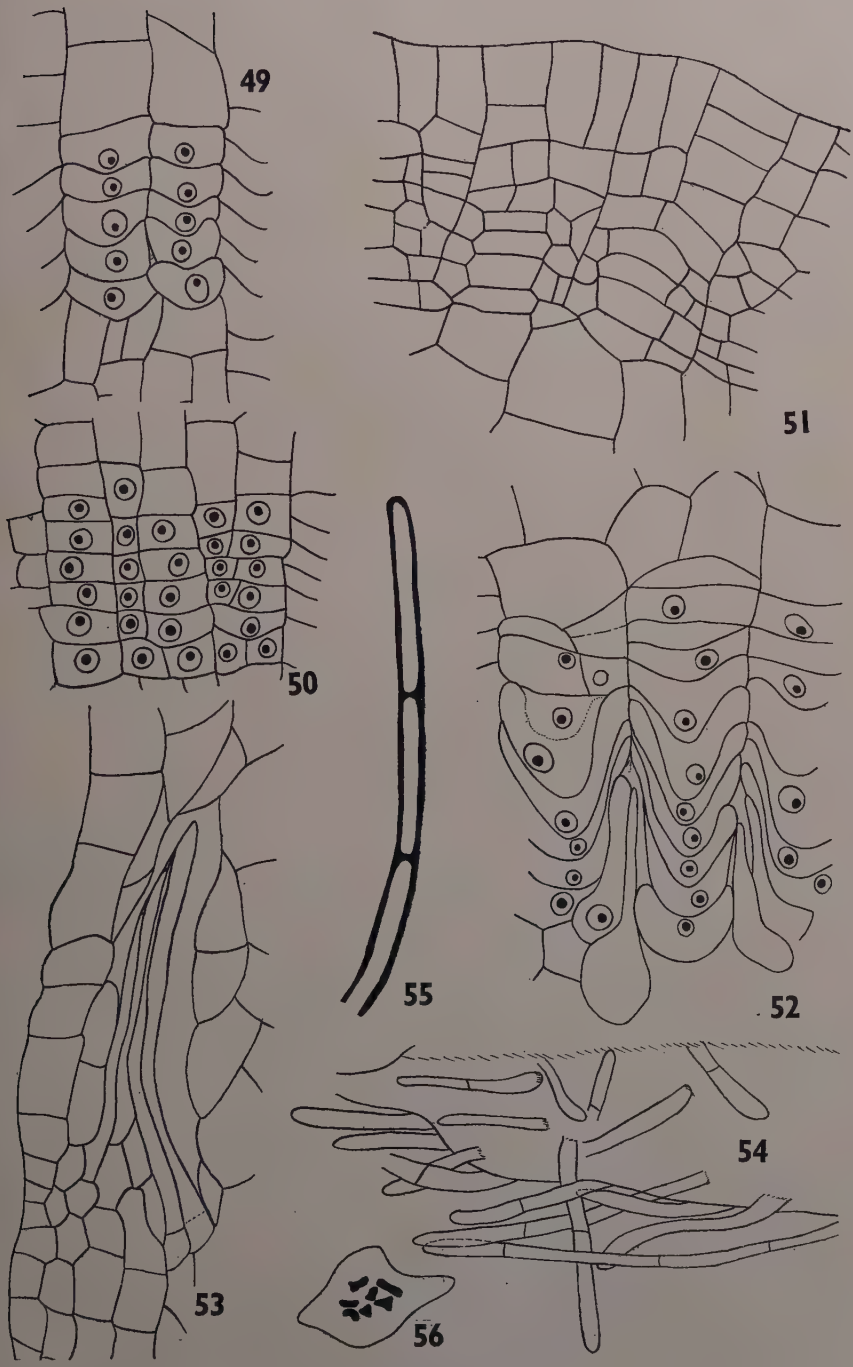
It consists of a single row of 32 solid teeth and the structure of a mature tooth (Text-Fig. 45) is essentially the same as in *Pogonatum stevensii*. But in that case initial stages of the development of peristome could not be made out very clearly. As seen in the present species, its development starts along with the differentiation of other parts of the capsule (Text-Fig. 46). There are 32 sectors of amphithecial cells which form the peristome (Text-Fig. 47) and these cells are four to five cells high as seen in a radial longitudinal section (Text-Fig. 48) and tangential longitudinal section (Text-Fig. 49). These cells later on cut off one or two smaller cells on their sides as seen in tangential longitudinal section (Text-Fig. 50) and transverse section (Text-Fig. 51) which may also divide further to form 32 groups of tangentially elongated cells alternating with 32 groups of smaller cells (Text-Fig. 51). After this the elongation of these cells takes place (Text-Fig. 52) as described in *Pogonatum* to form the mature teeth. As the peristome is developing the upper walls of the top U-shaped elongating cells disorganize to separate one tooth from the other (Text-Figs. 52 and 45). The attachment of the peristome to the rim of the theca is direct and there is no distinct basal attaching membrane (Text-Fig. 53).

CALYPTRA

In this species the calyptra is non-hairy for taxonomic purposes but some hairs do develop in the initial stages near the top (Text-Fig. 54). Each hair is a uniseriate filament of few thick-walled cells and is not branched (Text-Fig. 55). The hairs are not produced later on and those already present also fall down gradually so that when the capsule is about to mature, no hairs are seen in the calyptra.

SPOROGENESIS AND CHROMOSOME NUMBER

Sporogenesis is very normal and four seemingly viable spores are formed from a single spore mother cell. During meiosis seven bivalents are seen at diakinesis in a mother cell (Text-Fig. 56). The bivalents are of various sizes but no distinctly larger (M) or distinctly smaller (*m*) bivalent is observed.



TEXT-FIGS. 49–56

TEXT-FIGS. 49–56. Figs. 49, 50. Parts of Tangential longitudinal sections of capsule from peristome region showing two stages of development, ×600. Fig. 51. A part of the C.s. of capsule (peristome region) showing groups of smaller and tangentially elongated cells, ×600. Fig. 52. Elongation of peristome cells as seen in Tangential longitudinal section, ×600. Fig. 53. L.s. mature tooth showing attachment, ×400. Fig. 54. Hairs on the calyptra (whole mount), ×270. Fig. 55. A single hair, ×270. Fig. 56. Seven bivalents at diakinesis in a spore mother cell, ×900.

DISCUSSION

The lateral buds on a protonema is the general rule in mosses and passing of a protonema into a terminal bud is an exception. A few interesting cases have already been recorded by Goebel (1905) in some primitive mosses where the persistent part of the life is protonema and the sexual branches are transitory forms.

(1) According to him in *Buxbaumia*, "At the end of a branch of a protonema there is formed a long-stalked antheridium".

(2) In *Schistostega*, "These protonema remain very short and each at its apex passes at once into the formation of a moss bud".

(3) In *Fissidens bryoides*, "The cell which becomes a male branch projects outward beyond the surface of the shoot, as if it were about to grow into a protonema thread but then without forming a protonema thread it passes at once into the formation of the apical cell of a shoot".

(4) He has also described the formation of simple shoots on the ends of protonema branches in *Ephemerum serratum*.

Of the four cases the first two and the *Ephemerum* belong to the Nematodonteæ of Dixon (1954) and thus this is a primitive character. Those who are inclined to favour algal ancestry for the mosses can say "Here we see how an alga-like protonema passes into the leafy gametophyte of mosses".

Just as the lateral buds on protonema are a rule in mosses, passing of the ephemeral protonema directly into a new plant is the rule in Hepatics. Here again Goebel (1905) has recorded a few exceptions.

Thus the stock or the stocks that gave rise to hepatics and musci had both these tendencies. During the course of evolution lateral buds on protonema became a rule in mosses and the converse in hepatics.

Antheridium development in *Oligotrichum* is remarkable in many ways:—

(1) The anacroanderous condition, the antheridia apparently in the axils of the leaves and a small filament of cells below the terminal cell, which develops an apical cell by two oblique walls, reminds us of the antheridia of Sphagnideæ.

(2) Its early segmentation is very similar to the development of the pedicel of the archegonium in this species and in *Atrichum* Palis (Chopra and Bhandari—in press).

This similarity gives further support to the hypothesis that the sex organs of bryophyta are homologous structures which is also favoured by Bryan (1927) on the basis of abnormal sex organs.

(3) Functional segments cut off androgonial and wall cells in the same fashion as in *Funaria* (Campbell, 1895).

(4) Some non-functional segments divide further in a manner very similar to the normal ones in *Pogonatum stevensii* (Chopra and Sharma, 1958).

(5) The division in some other segments recall to our mind the cutting off of the androgonial cell from wall cells in most of the hepatics.

Borrowing the expression used by Bryan (1915) in connection with the archegonium of *Sphagnum*, we may say that the antheridium of *Oligotrichum* is a synthetic type.

The terminal buds on protonema branches and the nature of the antheridium are further proofs of the primitive nature of the Polytrichales already described in our previous study on *Pogonatum*.

Summary

The life-history of *Oligotrichum semilamellatum* has been studied and it is practically on the same lines as that of *Pogonatum*. Besides lateral buds terminal ones are also noted on protonema branches. An abnormality in the segmentation of the apical cell of the stem has been noted where the segments are cut parallel to the flat surfaces. The development of the antheridium shows a number of variations. The archegonium first forms a pedicel by the activity of a three-sided apical cell which later becomes four-sided and ultimately five-sided to cut off four series of segments. The addition in the number of neck cells and neck canal cells is both apical and intercalary. The neck cells are not exactly superimposed resulting in the torsion of the neck. The sporophyte grows quite normally, the capsule has got two air spaces and the peristome is developed from the concentric rows of cells of the amphithecium which are four to five cells high from the start. The chromosome number is $n = 7$. The present study gives further support to the view that Polytrichales are a group of primitive mosses.

Our thanks are due to Prof. P. N. Mehra for going through the manuscript and making some useful suggestions.

References

Allsop, A. and Mitra, G. C. 1956. The Heterotrichous habit in the protonema of the Bryales. *Nature, Lond.* **178**: 1063–64.

BANNERJI, I. AND SUBIRSEN. 1956. The life-history of *Barbula indica* Bridel. *Proc. nat. Inst. Sci., India* **22**: 304–16.

BROTHERUS, V. F., PAUL, H. AND RUHLAND, W. 1924–25. *Musci* (Laubmoose) in *Nat. Pflanzenfam.* 2. Aufl. Bd. **10** und **11**: 25 Wihelm Englelmann, Leipzig.

BRYAN, G. S. 1905. The archegonium of *Sphagnum subsecondum*. *Bot. Gaz.* **59**: 40–56.

———. 1917. The archegonium of *Catharinea angustata* Brid. *Ibid.* **64**: 1–20.

———. 1927. Abnormal sex organs of *Mnium medium*. *Ibid.* **84**: 89–101.

CAMPBELL, D. H. 1895. *Structure and Development of Mosses and Ferns*. New York.

CHOPRA, R. S. AND SHARMA, P. D. 1958. Cytomorphology of the genus *Pogonatum* Palis. *Phytomorphology* **8** : 41–60.

DIXON, H. N. 1954. *Students Hand Book of British Mosses*. London.

GOEBEL, K. 1905. *Organographe*. English translation, Clarendon Press, Oxford.

HOLFERTY, G. M. 1904. The archegonium of *Mnium cuspidatum*. *Bot. Gaz.* **37**: 106–26.

*NARAYANASWAMI, S. 1957. The morphogenetic effects of various synthetic hormones on the gemmæ of *Tetraphis pellucida*. *Phytomorphology* **6**: 323–31.

—— AND LAL, M. 1957. Observations on regeneration in some Indian mosses. *Ibid.* **7**: 244–52.

VAIZEY, J. R. 1888. On the anatomy and development of sporogonium of mosses. *J. Linn. Soc. Bot.* **24**: 262-84.

* Quoted by Narayanaswami and Lal.

A DOUBLE FLOWER OF *TECOMELLA UNDULATA* SEEM

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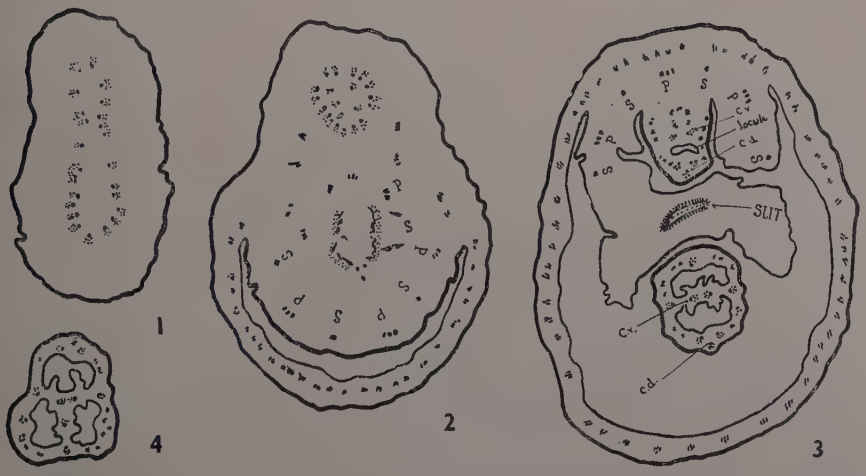
Normally the flowers of *Tecomella undulata* (Bignoniaceæ) are pentamerous, bicarpellary and the syncarpous gynœcium with axile placentation is borne on a long pedicel. During the examination of some material of this species a receptacle with two gynœcia was found. As it was a post-fertilization stage, no other floral organs were seen intact. The specimen was microtomed and sections were stained with gentian violet and erythrosin. Besides this, normal flowers and floral buds were also studied in a similar manner for comparison. The study yielded some features of morphological interest which are briefly recorded here.

On examination it was observed that the two gynœcia were borne on a common receptacle at different levels with a common calycine ring. They were separated by a conspicuous disc having a prominent slit in the centre (Text-Fig. 3). An interesting feature associated with one of the gynœcia was that it had a tricarpellary and trilocular gynœcium with axile placentation (Text-Fig. 4).



Text-Figs. 1–4. Cross-sections of the double flower of *Tecomella undulata*. Fig. 1. t.s. of the pedicel showing the compressed stele, ×50. Fig. 2. t.s. through the receptacle showing a circular stele for the flower with tricarpellary gynœcium

and traces for the bicarpellary flower (reconstructed), ×50. Fig. 3. t.s. showing traces for tricarpellary flower and bicarpellary gynœcium (ovules omitted), ×50. Fig. 4. Cross-section of the tricarpellary gynœcium (ovules omitted), ×80. (*D* = disc; *P* = petaline trace; *S* = staminal trace; *C. V.* = Carpellary Ventral.)

The pedicel has a ring of vascular bundles compressed laterally (Text-Fig. 1), while in a normal flower a circular ring is present. The pedicel gradually merges into the receptacle. From the receptacular stele traces for the calycine ring of the flower with bicarpellary gynœcium are given out. The origin and distribution of these traces conform to those of the calycine traces of a normal flower. These traces branch repeatedly to form a large number of vascular bundles in the calycine ring (Text-Fig. 2). Following these traces the stele becomes separated into two parts; the one which is circular in outline forms the vascular supply for the flower with tricarpellary gynœcium, while the other gives out ten traces in alternate succession for the second and the third whorls of the flower with bicarpellary gynœcium (Text-Fig. 2). Out of these, alternately five are smaller while the remaining five are larger and show branching. The behaviour of the smaller traces corresponds to that of staminal traces and those of the larger to that of the petaline traces of the normal flower. Hence it is logical to interpret them as belonging to the petaline and staminal whorls of the flower under study. The distribution of these traces indicates that the supply of the carpel is organized in a manner typical for a bicarpellary syncarpous gynœcium with axile placentation. At this level the vascular supply for the flower with tricarpellary gynœcium is marked off from the circular stele. The vascular supply of this flower is also given out exactly in the same manner as described for the flower with bicarpellary gynœcium. The difference being that here, there are four staminal and three petaline traces instead of five each. After this the supply for the gynœcium is formed which corresponds to that of a typical tricarpellary gynœcium with axile placentation.

As far as the vasculature of the flower with bicarpellary gynœcium is concerned it is perfect and similar in all respects with that of the normal; while the flower with tricarpellary gynœcium appears to have undergone suppression in the number of its sepals, petals and stamens. This reduction in the number of floral parts evidently appears to be due to fusion in between the two flowers. Curiously enough, it may be noted that this reduction in number of sepals, petals and stamens is associated with increase in the number of carpels. The increase in the normal number of carpels has been reported in several families of the Bicarpellatæ; *Datura fastuosa* and *Capsicum annuum* by Sundararaj, *et al.* (1954, 1955) and in *Linaria vulgaris* by Worsdell (1916). Trilocular gynœcium where bilocular one is a rule has also been reported for *Ixora coccinia*, *Mussaeanda frondosa* and *Oldenlandia umbellata* by Singh *et al.* (1953). Increase in the normal number of carpels is reported for the following genera: *Spilanthes*, *Cleome spinosa*, *Mimosa* sp., *Trifolium repens*, *Phaseolus multiflorus*, *Prunus amygdalus* and in double flower of *Ginkgo biloba* and *Delphinium* (Worsdell, 1916). Increase in number of carpels has been interpreted as a reversionary character by

Sundararaj *et al.* (1955). In this case, however, the double nature of the flower appears to be due to the partial fusion of the two flowers which is substantiated clearly by its anatomy. Besides these abnormalities described above, double whorls of petals have also been observed in this species during the course of present study.

Acknowledgement

I am grateful to Prof. B. Tiagi for guidance, to Prof. Dr. V. Puri, for going through the manuscript and helpful suggestions and to Prof. P. N. Mathur for the material.

References

Singh, T. C. N. and Kalyanasundaram, S. 1953. The occurrence of Tricarpellary Gynœcia in certain genera of the Rubiaceæ. *J. Indian Bot. Soc.* **32**: 64–66.

Sundararaj D. Daniel and Balasubramanyam, G. 1954. Abnormal Gynœcia. *Madras Agric. J.* **41**.

———. 1956. Abnormal carpellary conditions in a few plants. *Sci. & Cult.* **21**: 469–70.

Worsdell, W. 1916. *Principles of Plant Teratology*, **2**: London.

NOTES ON FUNGI FROM NORTH-EAST INDIA

IV. Myxomycetes

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The Myxomycetes or Mycetozoa are an interesting group of organisms with a life-history which makes them unique in fungi. This group of organisms received little attention in this country. Brühl and Sen Gupta (1927) made perhaps the first attempt at collecting and describing Myxomycetes from the University of Calcutta. Subsequently, Lodhi (1934) published a paper on the Indian Slime-Moulds (Myxomycetes) from the Punjab University which included 54 species. After nearly a lapse of two decades, the interest in Mycetozoa was revived by the writer from the University Botany Laboratory, Madras, and a series of articles were published on the slime-moulds occurring in and around Madras (Agnihothrudu, 1954 *a*, *b*, 1955, 1956 *a* and *b*). Concurrently, Thind and Sohi (1955 *et seq.*) began describing and illustrating Myxomycetes of the Mussoorie hills from the Department of Botany, University of Punjab.

The tea gardens in North-East India with the dense canopy of foliage, the decaying vegetable débris littered on the ground between bushes, coupled with the warm, humid weather that prevails during the monsoon months, in the experience of the writer afford excellent possibilities for mycological collection and notes concerning fungi, rare, undescribed or otherwise are being published from time to time from our laboratory (Agnihothrudu and Barua, 1957 *a*, *b*; Agnihothrudu, 1958 *a*, *b*, *c*, 1959 and Agnihothrudu and Hadfield, 1959).

The present paper embodies notes on some Myxomycetes collected by the writer (V. A.) and his collaborators, Messrs. H. K. Phukon (H. K. P.) and G. C. S. Barua (G. C. S. B.) during the routine work of identifying diseases incident to tea and ancillary crops. The 51 species of Myxomycetes dealt in this paper were mostly collected between 1957 and 1958 in and around Tocklai Experimental Station, Cinnamara, where the Scientific Department of The Indian Tea Association is situated.

As I am of the opinion that the practice of publishing mere lists of species from particular localities without describing the characters upon which the determinations were made, make such records valueless, I have attempted to illustrate and describe most of the forms occurring

here. Determinations were based on material which the writer considered to be quite mature and the present list comprises only those species which the author could identify with reasonable certainty with the help of the illustrious monographs on Mycetozoa by Lister (1925) and Martin (1949).

Determinations of unusual, little known, or intermediary forms are avoided scrupulously and further work on these and others, we are likely to come across during our collections, will be reported from time to time.

The entire collection is deposited in the Mycological Herbarium, Tocklai Experimental Station (M.H.T.E.S.).

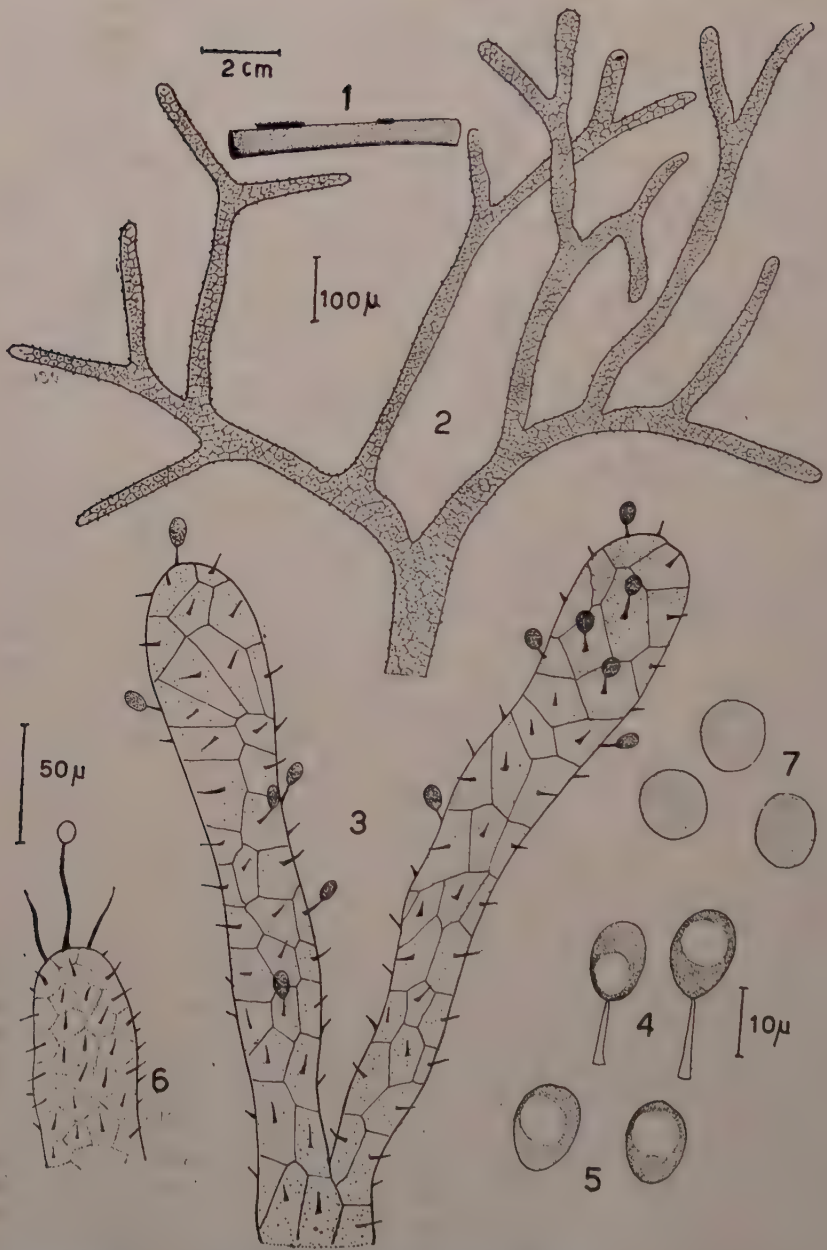
1. ***Ceratiomyxa fruticulosa* (Müller) Macbride** in *North American Slime-Molds*, p. 18, 1899; Lister, A., *A Monograph of the Mycetozoa*, pp. 4–5, 1925, as *Ceratiomyxa fruticulosa* Macbride; Martin, G. W., *North American Flora, Fungi-Myxomycetes*, pp. 7–8, 1949.

This species is very often encountered on tea bushes infected by root rots like *Fomes lamaœnsis* (Murr.) Sacc. and Trott. and *Ustulina zonata* (Lév.) Sacc. It is often observed within the bole of the tea stems which are in the process of decay. The fructifications are produced abundantly, snow-white to dirty-white in colour and effuse. White, watery plasmodia were observed. The fructifications are about 1 to 6 mm. in height and are in a few cases very extensive spreading over 15 to 25 cm. Spores are produced exogenously and borne at the apices of spicules on the fertile arms of the fructification. They are hyaline, predominantly oval or subelliptic with a prominent guttule and measure 8–10 (–12) × 4–5 (–6) μ in diameter (Text-Figs. 1 to 5).

It may be mentioned here that the growth habit of no two collections was identical and the typical fructifications as described and conceived either by Lister (1925) or Thind and Rehill (1957) with simple or sparsely forked, fasciculate fructifications were not at all observed locally. In the same collection, however, sporophores densely compacted to form a honey-comb-like growth comparable to var. *poroides* Alb. and Schw. were observed. Collections which could conveniently be classified under var. *arbuscula* Berk. and Br. and var. *filiformis* Berk. and Br. were also common on the same piece of decaying wood. These two varieties have been combined by Lister into one variety, namely, *flexuosa*. Except for growth form, there is indeed hardly any reasonable difference in microscopic details between these varieties.

In the form that could be assigned to var. *arbuscula*, the sporophores are rather stouter and flattened while in *filiformis*, the branches are more slender and almost terete. In either variety, however, the adjoining branches interlace to form a dense surface reticulum.

Hagelstein (1936) regards that these varieties, although they may be considered as such are not bound by geographical limits. They



TEXT-FIGS. 1–5. *Ceratiomyxa fruticulosa* (Müll.) Macbride (M.H.T.E.S. No. 2). Fig. 1. Fructifications on a small tea twig. Fig. 2. Fertile ramifications of the fructification. Fig. 3. The ultimate branches of the fructification. Fig. 4. Spores attached to the spicules. Fig. 5. Spores.

TEXT-FIGS. 6–7. *Ceratiomyxa spærosperma* Boedijn (M.H.T.E.S. No. 6). Fig. 6. Apical part of a fertile ultimate branch showing the elongated spore-bearing spicules. Fig. 7. Spores.

may after all be an expression of varied growth habit in response to the environmental conditions under which the fructifications are produced in nature. It is unfortunate that a phase developed under adverse environmental condition should be regarded as a discrete, distinctive taxon. The writer is in complete agreement with Martin (1949) and Hagelstein (1936) in lumping all varieties under *Ceratiomyxa fruticulosa* (Müll.) Macbride.

On decaying frames of tea, Tocklai, Coll.: V. A., 1–7–1957 (M.H.T.E.S. No. 2); on undetermined bark, Cinnamara Tea Estate, Coll.: V. A., 6–4–1958 (M.H.T.E.S. No. 3); on bark of tea bush infected by *Ustulina zonata* (Lév.) Sacc., Tocklai, Coll.: H. K. P., 7–7–1958 (M.H.T.E.S. No. 4); on the bark of a tea bush infected by *Fomes lamaœnsis* (Murr.) Sacc. and Trott., Tyroon, T. E., Coll.: 4–5–1957 (M.H.T.E.S. No. 5).

2. ***Ceratiomyxa sphaerosperma* Boedijn** in *Misc. Zool.*, **24,** p. 1, 1927; Martin, G. W., *North American Flora, Fungi-Myxomycetes*, p. 7, 1949.

Only two collections of this interesting species were made from Tocklai campus. Plasmodium not observed. Fructifications minute, scattered to gregarious, whitish turning pale yellowish on drying and exposure. Each fructification has a distinct stalk bearing at the tip, irregularly dichotomising arms. The branching is limited and not much repeated as in *C. fruticulosa*. Spores are typically globose or subglobose and are borne on spicules scattered all over the arms of the fructification. Ultimate branches measure up to 50 μ broad. The spore-bearing spicules are generally 4–6 (–8) μ long but those at the apices of the branches are exceptionally elongated measuring 18-20 (–22) μ long. Spores 8–10 (–12) μ in diameter, hyaline, globose to subglobose with or without a conspicuous guttule (Text-Figs. 6–7).

The species is distinct from *C. fruticulosa* in having spherical to subglobose spores, the sparsely branching habit and the elongated spore-bearing spicules that beset the apices of the arms of fructifications.

This species of *Ceratiomyxa* was first described by Boedijn (1927) from Sumatra and later on from the island of Krakatoa (Boedijn, 1940). Martin (1942) described the same species from Barro Colorado Island, Panamá Canal Zone on fruits of *Apeiba tibourbou* Aubl. and from Castilla, Limon Province, Costa Rica. Alexopoulos and Benecke (1954) reported *C. sphærosperma* from Jamaica. Both the Panamá and Costa Rica collections appear to differ from the type species in being longer, more slender stalked and in the larger number of branches. The form occurring here in Assam tallies more with the new world collection than with Boedijn's (1927) original description.

On the bark of tea infected by *Fomes lamaœnsis* (Murr.) Sacc. and Trott., Tocklai, Coll.: V. A., 4–8–1957 (M.H.T.E.S. No. 6); on tea roots, Tocklai, Coll.: H. K. P., 12–7–1958 (M.H.T.E.S. No. 7).

3. ***Lycogala exiguum*** **Morgan** in *J. Cincinn. Soc. nat. Hist.*, **15**, p. 21, 1893; Martin, G. W., *North American Flora, Fungi-Myxomycetes*, p. 21, 1949; Lister, A., *A Monograph of the Mycetozoa*, p. 199, 1925, as *Lycogala epidendrum* Fries var. *exiguum* Lister.

Only two collections are preserved in the herbarium. Aethalia few and scattered; spherical to subglobose, measuring up to 3 mm. in diameter; cortex prominent, honey-coloured, thickly beset with purplish, later on turning black, scale-like mottles which are internally divided into numerous chambers. Dehiscence of the æthalium is by an apical rupture which may become irregular or stellate. Pseudocapillitium lax, concolorous with cortex composed of sparingly branched tubules arising from the inner portion of the cortex, somewhat wrinkled transversely, measuring 4–8 (–10) μ in diameter; spores brown in mass, pale ochraceous to almost hyaline in transmitted light, spherical ornamented with indistinct warts, measuring 4–5 (–6) μ in diameter. Plasmodium not observed (Text-Figs. 8–13).

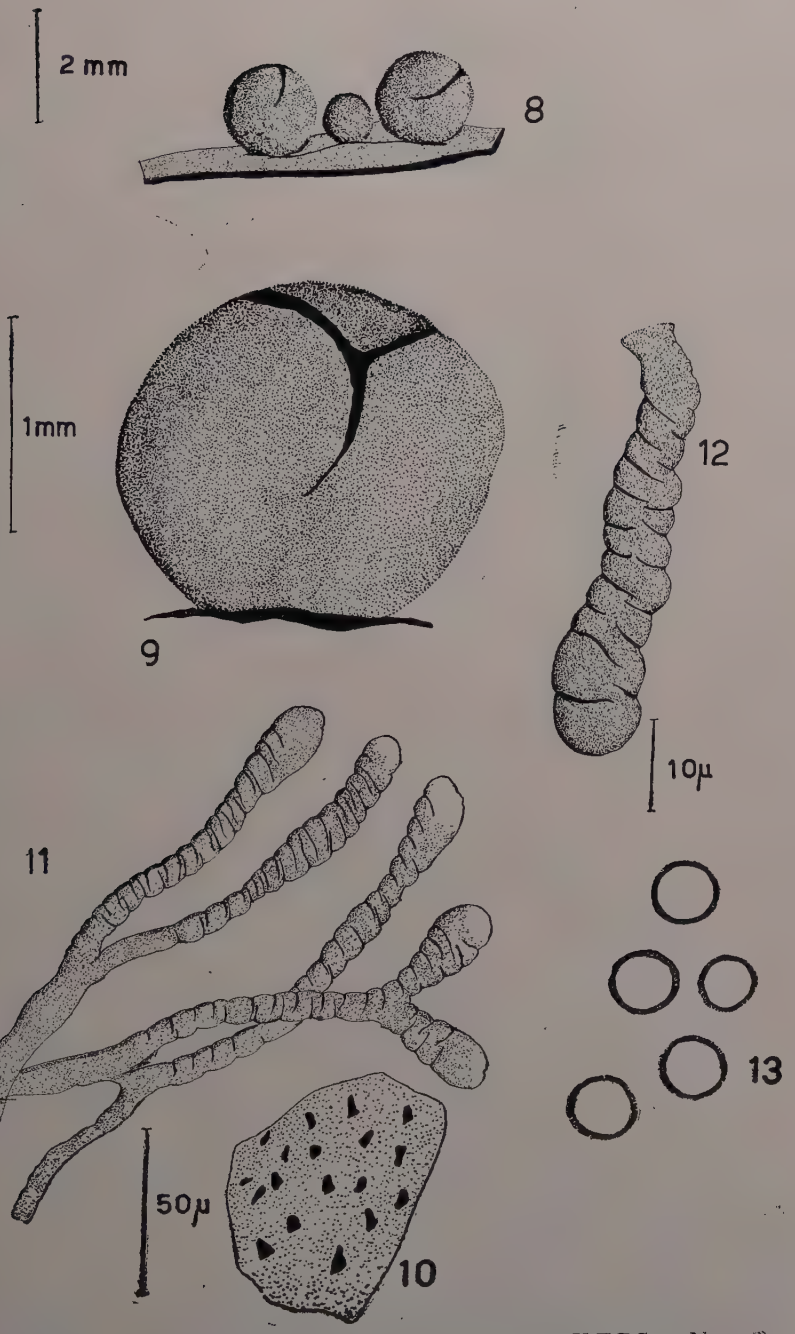
The form may easily be mistaken for *Lycogala conicum* Persoon, but on careful examination could be readily separated. *L. exiguum* has similarly coloured peridium thickly beset with coarse, black warts between which are clusters of smaller thickenings which give a blackish appearance to the whole. The Listers (1925) have regarded this as a variety of *Lycogala epidendrum* (L.) Fries.

The forms collected here obviously possess characters stressed by Morgan (1893) in establishing the species *L. exiguum*, namely, the rather slender threads of the pseudocapillitium and the reticulate surface pattern made by the dark scales on the cortex. The scales show the characteristic tesellate appearance in a few æthalia. May be that this tesellate nature of the peridium shows wide range of variation as suggested by Martin (1947).

On undetermined bark, Jorhat, Coll.: H. K. P., 11–11–1957 (M.H.T.E.S. No. 8); on tea branch suffering from branch canker caused by *Poria* sp., Cinnamara T.E., Coll.: V. A., 14–7–1958 (M.H.T.E.S. No. 9).

4. ***Reticularia lycoperdon*** **Bulliard** in *Histoire Champignons de la France*, p. 95, 1791; Lister, A., *A Monograph of the Mycetozoa*, pp. 195–96, 1925; Martin, G. W., *North American Flora, Fungi-Myxomycetes*, p. 22, 1949.

Only three collections of this species were made. Plasmodium not observed. Aethalia typically pulvinate, globose to subglobose, up to 2 cm. in diameter, at first silvery white and iridescent becoming coppery on withering, seated on a prominent well-developed hypothallus



TEXT-FIGS. 8–13. *Lycogala exiguum* Morgan (M.H.T.F.S. No. 8). **Fig. 8.** Aethalia on a decaying bark. Fig. 9. Aethalium showing the mode of

dehiscence. Fig. 10. Peridial wall showing the speckled nature. Figs. 11 and 12. Capillitial threads. Fig. 13. Spores.

which forms a conspicuous margin at the base of the æthalium; pseudocapillitium abundant consisting of persistent portions of the peridial wall, forming irregularly ramifying strands arising from the persistent hypothallus. The pseudocapillitium is frayed above into numerous slender, flattened and flexuose rusty-brown threads. Spores abundant buff to pale ochraceous-brown or rusty in colour, subglobose, faintly reticulate over about two-thirds of the surface, measuring 7–8 (–10) μ in diameter (Text-Figs. 14–17).

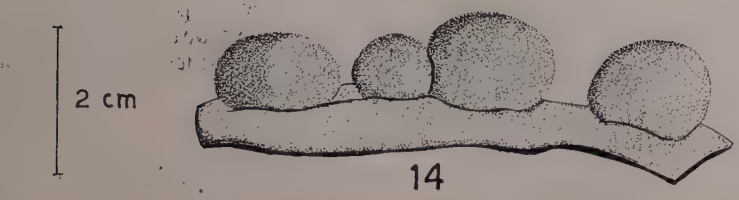
The collections were first identified as *Enteridium rozeanum* (Rost.) Wingate but critical examination revealed them to be devoid of the perforated, flattened pseudocapillitium attached to the brown cortex which is so characteristic of this species. In fresh collections, the spores germinated within an hour producing amœboid swarm cells, but in specimens which were more than a year old the spores took more than three hours for germination.

The collection made locally differs from the typical description of the species in being much smaller and in possessing fragile, coppery, areolate surface walls and faint reticulation of spores which are pale rusty-brown in colour. The characters are more in keeping with the description of *Reticularia jurana* Meylan (1908) which is treated as a synonym of *R. lycoperdon* by Lister (1925) as well as Martin (1949).

On undetermined bark, Jorhat, Coll.: H. K. P., 15–7–1957 (M.H.T.E.S. No. 10); on soil between tea bushes, Tocklai, Coll.: V. A., 14–4–1958 (M.H.T.E.S. No. 11); on undetermined substratum, Jorhat, Coll.: H. K. P., 11–6–1958 (M.H.T.E.S. No. 13).

5. ***Dictydium cancellatum*** **(Batsch) Macbride** in *North American Slime-Molds*, p. 172, 1899; Lister, A., *A Monograph of the Mycetozoa*, pp. 179–80; 1925 as *Dictydium cancellatum* Macbride; Martin, G. W., *North American Flora, Fungi-Myxomycetes*, p. 32, 1949.

Plasmodium not observed. Sporangia distinctly stalked, measuring up to 2 mm. in height, gregarious to subgregarious, subglobose, umbilicate, typically nodding, up to 0·75 mm. in diameter, dark reddish-brown in colour. Peridium delicate, ephemeral, except for the net, composed largely of longitudinal ribs extending from the base of the sporangium, up to 50 in number and about 5 μ in diameter, interconnected by transverse threads so that the meshes consist of rectangular areolæ. Calyculus almost absent; stalk stout at the base, arising from a prominent hypothallus, deep purple brown, deeply longitudinally striate, subulate, tapering towards the sporangial end and not infrequently slightly twisted or skewed, measuring up to 4 times the diameter of the sporangia. The peridial costæ become inflexed at the summit to give an umbilicate appearance to the sporangium. The ribs are made up of two distinct layers, the outer smooth and shining, the inner



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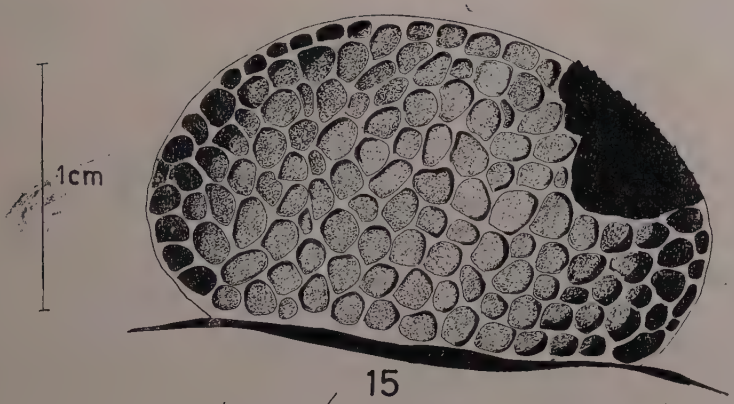

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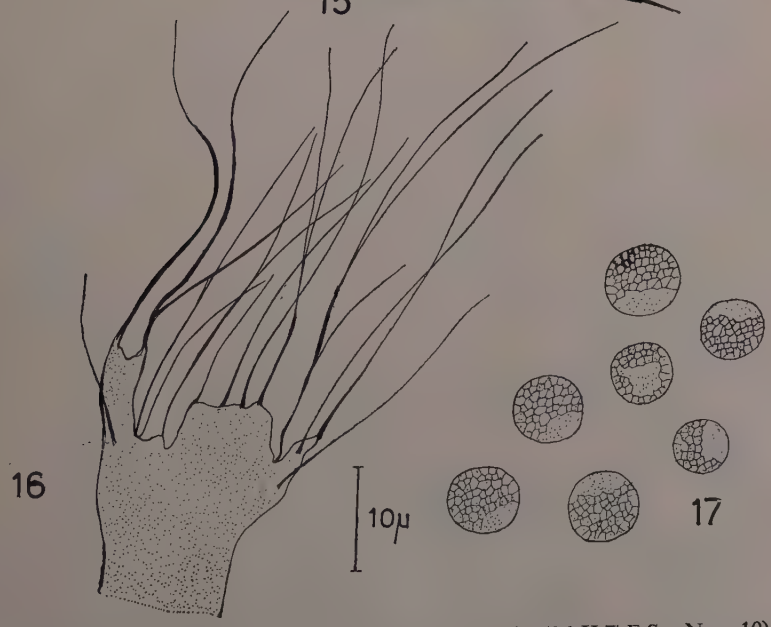
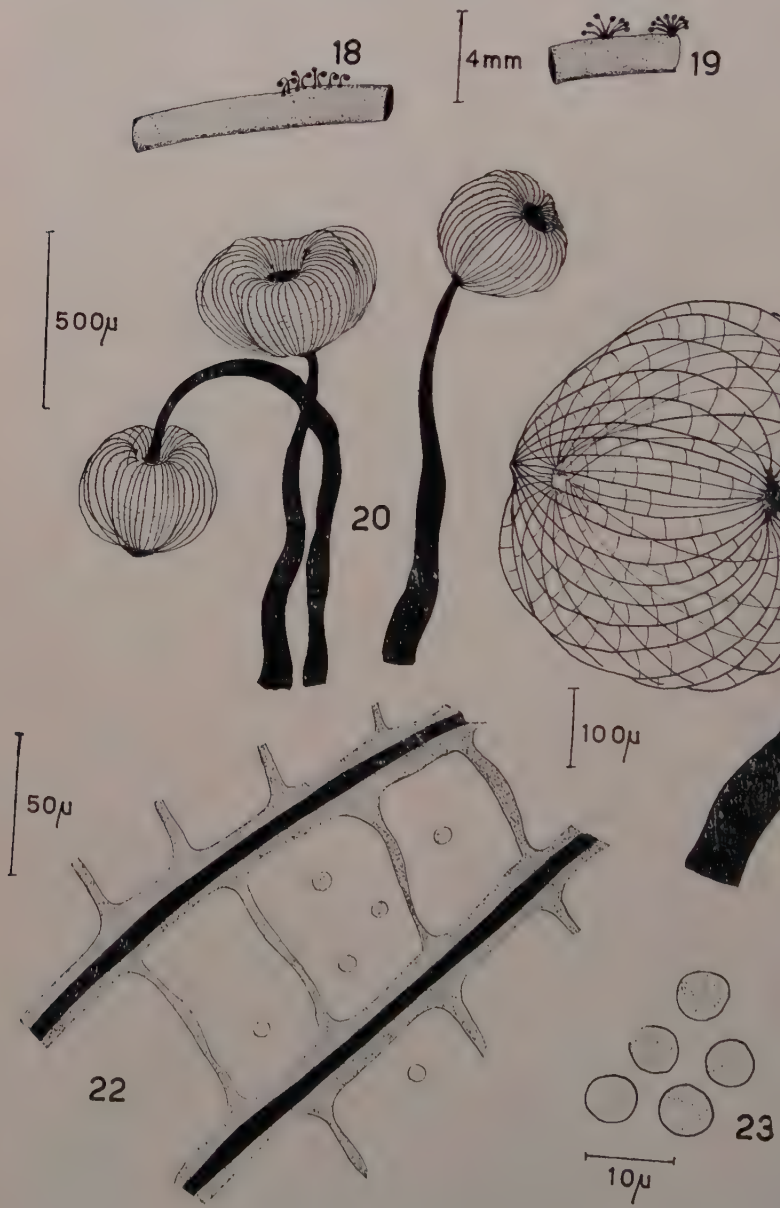


TEXT-FIGS. 14–17. *Reticularia lycoperdon* Bulliard (M.H.T.E.S. No. 10). Fig. 14. Aethalia on decaying bark. Fig. 15. An enlarged æthalium. Fig. 16. Capillitial threads. Fig. 17. Spores.

gorged with plasmodic or dictydine granules. Spores purplish in mass, pale reddish-brown in transmitted light, almost smooth, globose, 4–6 (–7) μ in diameter. No plasmodic or dictydine granules were observed on the spore wall (Text-Figs. 18–23).



TEXT-FIGS. 18–23

TEXT-FIGS. 18–23. *Dictydium cancellatum* (Batsch) Macbride. (M.H.T.E S. No. 15). Figs. 18 and 19. Scattered and gregarious sporangial groups. Fig. 20. Sporangium showing the well-developed stipe. Fig. 21. Sporangial head with the inflexed capillitial ribs. Fig. 22. Capillitial costæ, enlarged. Fig. 23. Spores.

On undetermined bark, Jorhat, Coll.: H. K. P. 24–6–1957 (M.H.T.E.S. No. 14); on tea frames infected by branch canker caused by *Poria* sp., Cinnamara T.E., Coll.: V. A., 20–7–1957 (M.H.T.E.S. No. 15); on bark of *Mesua ferrea* L., Jorhat, Coll.: H. K. P., 14–5–1958, (M.H.T.E.S. No. 16).

6. ***Perichaena vermicularis*** **(Schw.) Rostafinski** in *Mon. Appen.*, p. 34, 1876; Lister, A., *A Monograph of the Mycetozoa*, pp. 248–49, 1925, as *Perichæna vermicularis* Rost.; Martin, G. W., *North American Flora, Fungi-Myxomycetes*, p. 40, 1949; Agnihothrudu, V., *J. Indian bot. Soc.*, **35,** pp. 33–35, 1956.

Only one collection was made of this species on a decaying boll of cotton. The plasmodiocarps are slender and elongated with occasional rings of sporangia. The colour is ochraceous or umber and the typically verrucose inner layer of the peridial membrane is sufficiently distinctive to characterize this species from other members of *Perichæna*.

On decaying boll of cotton, *Gossypium arboreum* L., Tocklai, Coll.: V. A., 10–6–1957 (M.H.T.E.S. No. 172).

7. ***Perichaena depressa*** **Libert** in *Plantæ cryptogamicæ quas in Arduenna collegit*, p. 378, 1933; Lister, A., *A Monograph of the Mycetozoa*. pp. 244–45, 1925; Martin, G. W., *North American Flora, Fungi-Myxomycetes*, p. 40, 1949; Agnihothrudu, V., *J. Indian bot. Soc.*, **35,** p. 35, 1956.

Only one collection of this myxomycete was made on bark of *Aleurites montana* Wilson, found in association with *Haplosporella aleuritis* Agnihothrudu and Hadfield. Sporangia 0·1–0·5 (–0·75) mm. in diameter, and are rather smaller than the specimens collected at Madras (Agnihothrudu, 1956 *a*). The sporangia are very rarely separate, mostly gregarious and polygonal by mutual contact, honey-coloured, with a pale yellowish-brown margin which marks the line of circumscissile dehiscence of the peridium. Lime granules are present in the peridial wall. Peridium consists of two distinct layers, an outer layer which is thick and cartilaginous, charged with lime granules, and an inner minutely papillose layer. Capillitium is much sparse than in the South Indian collection; threads yellow, sparingly branched, up to 3 μ wide, marked with minute warts; spores deep citron yellow in mass, almost hyaline in transmitted light, spherical, minutely warted, measuring 8–9 (–11) μ in diameter.

The specimen under report differs from the typical *Perichæna depressa* in being much smaller in size, in the sparse capillitial threads and the slightly smaller size of spores and approaches *Perichæna quadrata* Macbride which is treated as a synonym of *P. depressa* by Martin (1949) and Hagelstein (1937).

Only one collection is preserved, fructifications underneath the bark of *Aleurites montana* Wilson. Tocklai, Coll.: V. A., 11–9–1958 (M.H.T.E.S. No. 17).

8. ***Arcyria versicolor*** **Phillips** in *Grevillea*, **5**, p. 115, 1877; Lister, A., *A Monograph of the Mycetozoa*, p. 231, 1925; Martin, G. W., *North American Flora, Fungi-Myxomycetes*, p. 47, 1949.

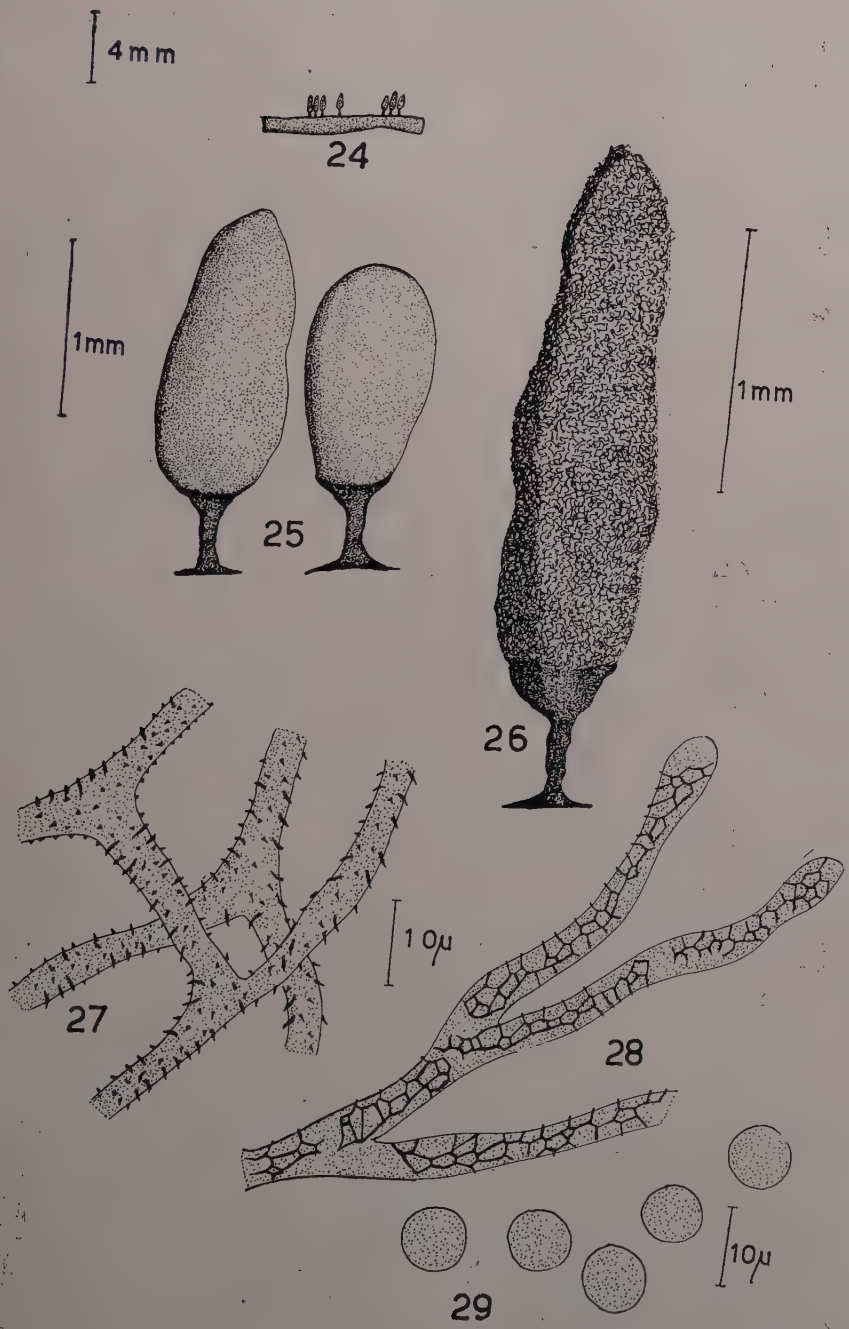
Plasmodium not observed. Only one collection is preserved in the herbarium. Total height of the sporangium up to 3 mm.; about 1·5 mm. before dehiscence, stalked, gregarious, elongate clavate to pyriform in shape, olivaceous yellow, glossy, turning olivaceous brown on dehiscence and exposure. Dehiscence usually beginning at the top, the peridial membrane is evanescent at the apex, persisting in the form of a cup at the base of the sporangium, yellow and papillose; stalk weakly developed, strand-like in some, up to 0·2 mm. long, yellow to yellowsih-brown, filled with spore-like cells, arising from a distinct, well-developed hypothallus, which may be verrucose; capillitium an elastic network of freely branching yellowish threads, measuring 4–5 (–6) μ in diameter, oval or triangular in section; marked with broken reticulations and spines; scarcely attached to the cup; spores, olivaceous brown or yellowish in mass, pale ochraceous in transmitted light, spherical to globose, almost smooth, measuring 8–9 (–11) μ in diameter (Text-Figs. 24–29).

This species could be readily distinguished from the yellow forms of *Arcyria ferruginea* Sauter in the shape of the sporangia, in the papillose nature of the peridial wall and in the smoother spores.

On decaying tea twigs, Tocklai, Coll.: V. A., 6–4–1957 (M.H.T.E.S. No. 173).

9. ***Arcyria cinerea*** **(Bulliard) Persoon** in *Synopsis Methodica Fungorum*, p. 184, 1801; Lister, A., *A. Monograph of the Mycetozoa*, pp. 231–32, 1925, as *Arcyria cinerea* Persoon; Martin, G. W., *North American Flora, Fungi-Myxomycetes*, p. 45, 1949; Agnihothrudu, V., *J. Indian bot. Soc.*, **33**, pp. 187–88, 1954.

This species is of frequent occurrence on the decaying litter in tea gardens. Only two specimens have been preserved in the herbarium. The colour of the sporangia is distinctly yellow when they are produced under shade. Sporangia exposed to sunlight are observed to possess pale greenish hue which subsequently turns cinereous. No pink forms were collected. Variation in shape of the sporangia in the same collection is common. Most of the forms observed are clavate to cylindric, although subglobose fructifications approaching *Arcyria pomiformis* (Leers) Rostafinski in form were once collected. They were very few. Notwithstanding the differences in colour, shape and size of the fructifications, the capillitium shows little or no variation in the ornamentation and is comparable with the South Indian collections (Agnihothrudu, 1954 *b*). In one instance a set of 4 or 5 sporangia grouped in a digitate fashion was collected which may be



TEXT-FIGS. 24–29

TEXT-FIGS. 24–29. *Arcyria versicolor* Phillips (M.H.T.E.S. No. 173). Fig. 24. Sporangia on a tea twig. Fig. 25. Sporangia with the peridium intact. Fig. 26. Sporangia without the peridium showing the expanded capillitial net. Figs. 27 and 28. Capillitium showing the ornamentation. Fig. 29. Spores.

placed conveniently in *A. cinerea* (Bull.) Pers. var. *digitata* (Schum.) G. Lister. It should, however, be mentioned here that in this collection the partially coalescent stipes retained their individual identity and separation at the base is widely divergent. It is most likely that the digitate form is one of the expressions of the conditions prevailing at the time when the plasmodium was resolving into sporangiate fructifications.

On undetermined bark, Titabar, Coll.: V. A., 12–3–1957 (M.H.T.E.S. No. 18); on tea root bark, Tocklai, Coll.: H.K.P., 22–8–1957 (M.H.T.E.S. No. 19).

10. ***Arcyria denudata* (L.) Wettstein** in *Verh. zool.—bot. Ges. Wien.*, **35,** p. 535, 1886; Lister, A., *A Monograph of the Mycetozoa*, pp. 235–36, 1925, as *Arcyria denudata* Wett.; Martin, G. W., *North American Flora, Fungi-Myxomycetes*, pp. 46–47, 1949; Agnihothrudu, V., *J. Indian bot. Soc.*, **35,** pp. 220–21, 1956.

This species is quite abundant and is readily recognized by its brick-red colour, fairly large size, long and dark coloured stalks and the capillitium firmly attached to the calyculus. The capillitial threads, as compared with the South Indian form are paler (pale pinkish) in colour, stouter (up to 7·5 μ in diameter) and beset with loose spirals of smooth cogs or half rings.

On tea bark, Cinnamara, T. E., Coll.: V. A., 14–3–1957 (M.H.T.E.S. No. 20); on undetermined wood, Jorhat, Coll.: V. A., 21–3–1957 (M.H.T.E.S. No. 21); on decaying frames of tea bush, Tocklai, Coll.: H. K. P., 7–6–1957 (M.H.T.E.S. No. 22); on tea roots, infected by *Ustulina zonata* (Lév.) Sacc., Borbhetta experimental plots, Coll.: V. A., 10–6–1957 (M.H.T.E.S. No. 23); on undetermined wood Nazira, Coll.: G. C. S. B., 15–8–1957 (M.H.T.E.S. No. 24); on decaying wood of *Albizzia moluccana*, Coll.: V. A., 1–1–1958 (M.H.T.E.S. No. 26); on undetermined bark, Jorhat, Coll.: H. K. P., 10–3–1958 (M.H.T.E.S. No. 27); on undetermined wood, Jorhat, Coll.: V. A., 30–6–1958 (M.H.T.E.S. No. 28).

11. ***Arcyria ferruginea* Sauter** in *Beiträge zur kenntniss der Pilze—Vegetation des Oder-Flora*, **24,** p. 316, 1841; Lister, A., *A Monograph of the Mycetozoa*, pp. 229–31, 1925; Martin, G. W., *North American Flora, Fungi-Myxomycetes*, pp. 43–44, 1949; Agnihothrudu, V., *J. Indian bot. Soc.*, **35,** pp. 36–37, 1956.

This species appears to be quite common but the local collections are somewhat different from those reported by the writer from South India (Agnihothrudu, 1956 *a*). The sporangia are about 2·5 mm. in total height, highly elastic, expanding to about 4·0 mm. in total height

after dehiscence; the colour is predominantly brownish, with a reddish tinge. The capillitial threads are about 6 μ in diameter, varying little from the basal threads which are not infrequently lax. The spores of the local form are smaller measuring 8–9 (–10) μ.

It is very obvious that the form occurring here differs from the South Indian collection in certain morphological details, in being larger in size, brownish in colour and possessing a capillitium of uniform thickness and smaller spores which are mostly a trifle under 10 μ in diameter.

On leaf blade of *Artocarpus integrifolia* L., Jorhat, Coll.: H. K. P., 14–4–1957 (M.H.T.E.S. No. 29); on an undetermined twig, Jorhat, Coll.: H. K. P., 21–6–1958 (M.H.T.E.S. No. 30).

12. ***Arcyria assamica*** **Agnihothrudu** in *J. Indian bot. Soc.*, **37,** pp. 499–503, 1958.

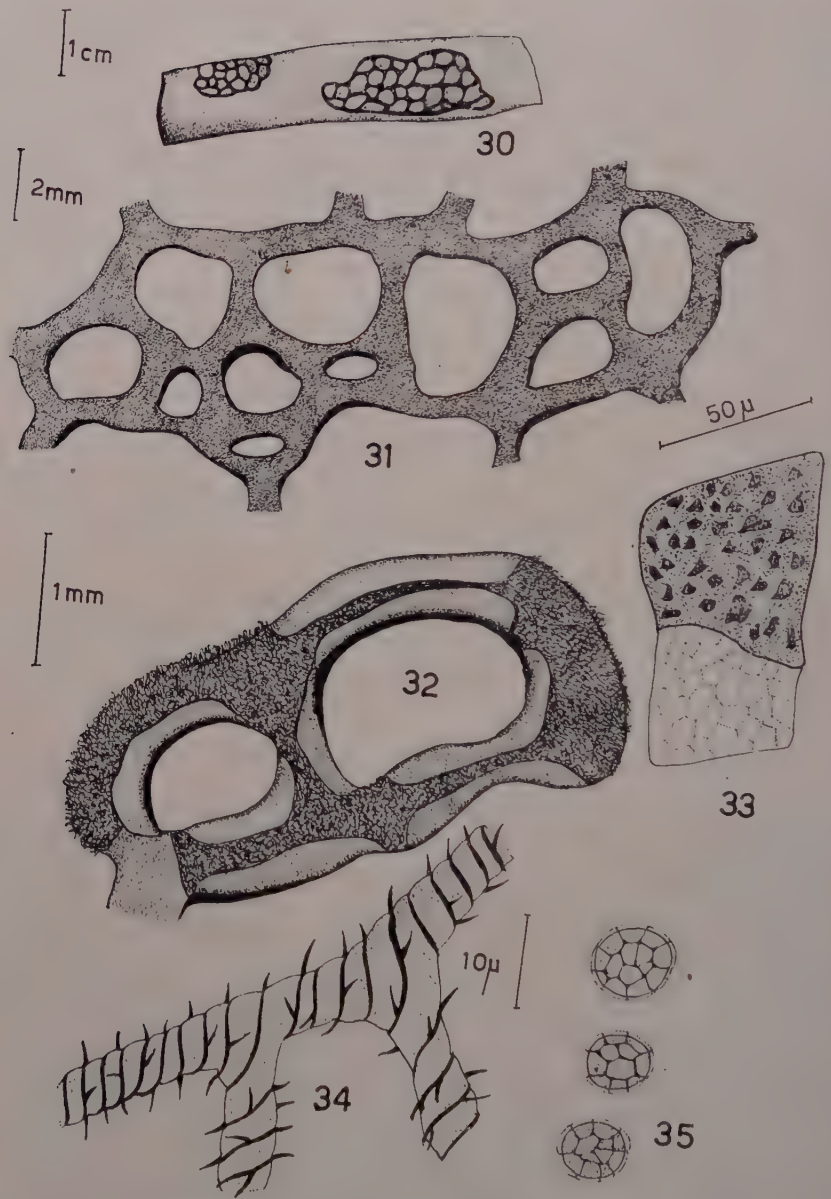
Besides the collections reported earlier (Agnihothrudu, 1958 *c*) one more collection of this interesting species was made on decaying frames of tea infected by *Poria* sp., Tockali, Coll.: V. A., 4–5–1958 (M.H.T.E.S. No. 91).

13. ***Hemitrichia serpula*** **(Scopoli) Rostafinski** in *Versuch eines System der Mycetozœn*, p. 14, 1873; Lister, A., *A Monograph of the Mycetozoa*, pp. 224–25, 1925, as *Hemitrichia serpula* Rost.; Martin, G. W., *North American Flora, Fungi-Myxomycetes*, pp. 55–56, 1949; *Mycologia*, **40,** pp. 125–26, 1948; Thind, K. S. and Sohi H. S., *Indian Phytopath.*, **9,** p. 91, 1956.

Extensive fruitings of this myxomycete were collected. The plasmodiocarps which are bright golden yellow to tawny are formed on the surface of wood or litter, extending over several centimetres in diameter. Plasmodium yellow. Plasmodiocarps up to 0·5 mm. in diameter, usually uniting into a close well-formed net seated on a prominent, tawny or deep brownish hypothallus; peridium consisting of two distinct layers, the outer membranous, delicately reticulate with a vague network. The peridium dehisces longitudinally and irregularly; capillitium a highly elastic tangle of twisting, sparsely branched, slender yellow threads, up to 6 μ in diameter, free everywhere except below, marked with 3–4 well-defined regular spiral bands, spinulose, without any traces of longitudinal striæ; the free tips of the capillitium are few and spiny; spores deep yellowish in mass, faint yellowish to almost hyaline in transmitted light; globose, bearing reticulate thickenings with narrow bands forming a net of 8–12 meshes to the hemisphere, measuring 10–12 (–14) μ in diameter (Text-Figs. 30–35).

In one particular instance the plasmodiocarp net was very extensive and measured about 10–12 cm. long and 6–7 cm. broad.

On undetermined dicotyledonous twiner, Nazira, Coll.: G. C .S. B., 15–8–1957 (M.H.T.E.S. No. 31); on the decaying culms of a reed grass,



TEXT-FIGS. 30–35. *Hemitrichia serpula* (Scopoli) Rostafinski (M.H.T.E.S. No. 35). Fig. 30. Plasmodiocarp on a decaying tea twig. Fig. 31. The reticulate plasmodiocarp. Fig. 32. Plasmodiocarp showing the dehisced peridial lobes and the capillitium. Fig. 33. Peridial walls showing the outer cartilaginous layer with refuse matter and the inner membranous delicately reticulate layer. Fig. 34. Capillitium. Fig. 35. Spores.

Nazira, Coll.: G. C. S. B., 15–8–1957 (M.H.T.E.S. No. 32); on decaying leaf-sheath of *Areca catechu* L., Nazira, Coll.: G .C. S. B., 15–8–1957 (M.H.T.E.S. No. 33); on leaf blades of *Musa paradisiaca* L., Nazira, Coll.: G. C. S. B., 15–8–1957 (M.H.T.E.S. No. 34); on decaying wood of tea, Tocklai, Coll.: V. A., 14–6–1958 (M.H.T.E.S. No. 35).

14. ***Hemitrichia stipitata* (Massee) Macbride** in *North American Slime-Molds*, p. 207, 1899; Martin, G. W., *North American Flora, Fungi-Myxomycetes*, p. 58, 1949.

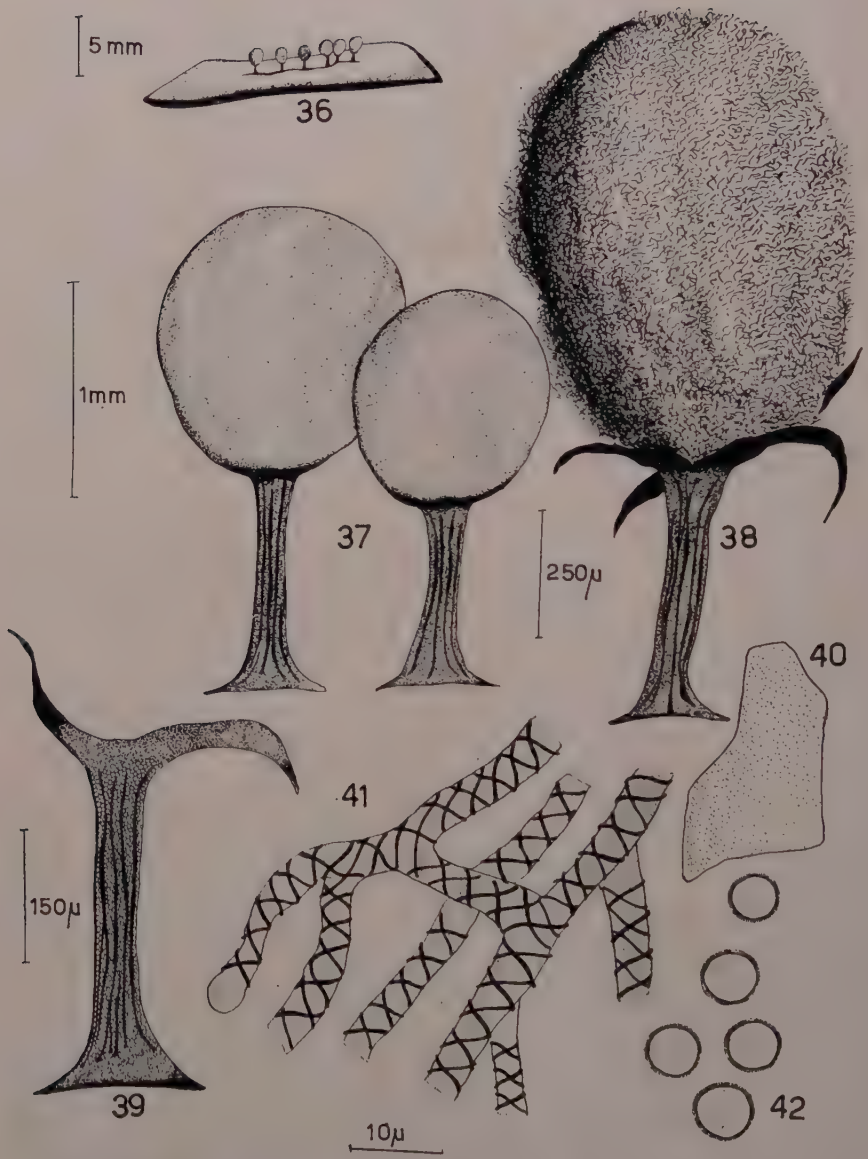
Plasmodium not observed. Fructifications are typically sporangiate, distinctly stipitate; scattered or aggregated in groups of four or more in number, globose not infrequently turbinate or top-shaped, measuring up to 3 mm. in height. Stalk, 0·5–1·5 mm. long, of uniform diameter, furrowed, shining, ochraceous or yellowish olivaceous in colour, arising from a thin spreading, reddish hypothallus filled with spore-like cells which are isodiametric; peridium thin, dirty yellow in colour, dehiscing at the top of the sporangium and reflexing to form a petaloid calyculus. Capillitium yellow, a dense tangle of pale yellowish threads which are elastic, with a few free ends which are obtuse; the threads are 4–5 (–7) μ in diameter with 4 or 5 spirals, smooth; spores globose to spherical, yellowish in mass, pale yellow to almost hyaline in transmitted light, minutely warted, measuring 6–7 (–8) μ in diameter (Text-Figs. 36–42).

In some collections, it was observed that there are forms which could be placed both in *Hemitrichia clavata* (Pers.) Rost. as well as in *H. stipitata* (Massee) Macbride. The above is the description of what the author believes to be a typical representative of *H. stipitata sensu* Martin (1949) which he characterizes as possessing a cylindrical stalk, that could be clearly differentiated from the shallow cup-like base of the persistent peridium and a smooth capillitium.

The predominantly occurring form has a long, fairly thin stalk rather weak at the apex so that often sporangia are of the nodding type. The cup of the sporangium is shallow, the peridium turned down over the stipe, being brittle breaks away in small circular plates. The capillitium is typically smooth, unlike *H. clavata* where it is minutely roughened, and free ends are very few or almost absent. The writer feels that the characters which differentiate the two species are rather subtle and are not sufficiently distinctive.

On decaying wood of *Albizzia procera* Benth., Tocklai, Coll:. H.K.P., 4–5–1957 (M.H.T.E.S. No. 35); on undetermined wood, Jorhat, Coll.: H. K. P., 8–8–1957 (M.H.T.E.S. No. 36); on bark of *Mangifera indica* L., Jorhat, Coll.: V. A., 30–8–1957 (M.H.T.E.S. No. 37); on root bark of a tea bush from waterlogged area, Tocklai, Coll: V.A., 10–12–1957 (M.H.T.E.S. No. 38).

15. ***Diachaea leucopodia* (Bulliard) Rostafinski** *Śluzowców* (*Mycetozoa*) *Monografia*, p. 190, 1874; Lister, A., *A Monograph of the Mycetozoa*, p. 101, 1925, as *Diachæa leucopoda* Rost., Martin, G. W.,



TEXT-FIGS. 36–42. *Hemitrichia stipitata* (Massee) Macbride (M.H.T.E.S. No. 37). Fig. 36. Fructifications on decaying bark. Fig. 37. Undehisced sporangia with the peridium intact. Fig. 38. Dehisced sporangia showing the petaloid peridial remnants and expanded capillitium. Fig. 39. Stipe bearing peridial remnants and spore-like cells. Fig. 40. A fragment of the peridium. Fig. 41. Capillitial threads showing the ornamentation. Fig. 42. Spores.

North American Flora, Fungi-Myxomycetes, p. 70, 1949; Thind, K. S. and Sohi, H. S., *Indian Phytopath.*, **9**, p. 161, 1956.

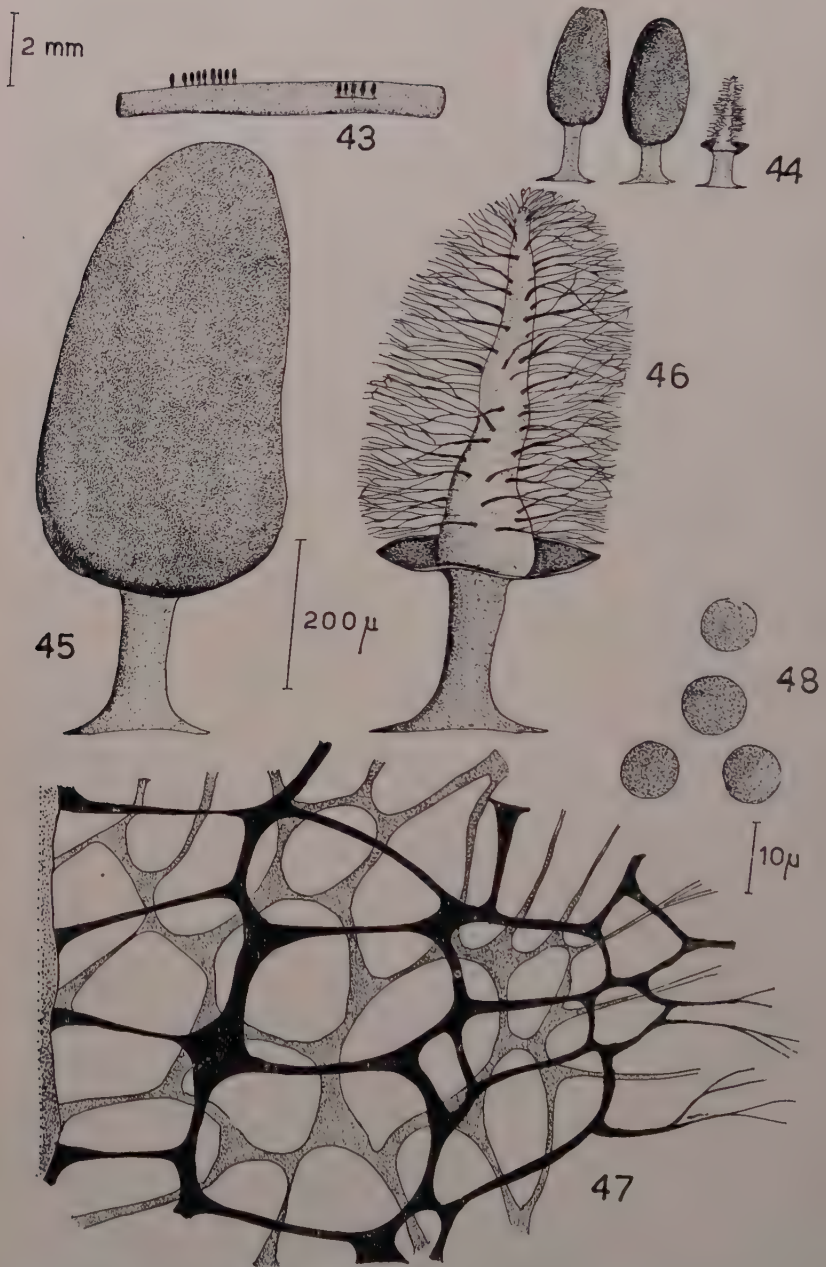
This species is abundant and of frequent occurrence forming large plasmodia which resolve into hundreds of beautiful, short, erect sporangia. A typical collection was made on vegetable débris from Nazira by G. C. S. B. Plasmodium in most of the collected specimens is dried up and opaque white in colour. Sporangia gregarious, cylindrical, obtuse to truncate, stalked, up to 1·5 mm. tall and 0·25 mm. wide, purple when immature, turning iridescent and then almost steel blue when fully formed with a membranous hyaline peridium. Stalk thick, milk-white, subulate, brittle, at times pale reddish-brown, about one-third to one-fourth the total height of the sporangium, distinctly striate, charged with lime granules, arising from a white well-formed discrete or sometimes confluent hypothallus which is also densely impregnated with calcareous granules. Columella present, thick, tapering, cuneiform, blunt, white, calcareous, reaching almost the summit of the sporangium. Capillitium consisting of profusely ramified and anastomosing threads connecting the columella with the sporangial wall; dark purple brown, almost hyaline at the extremities. Spores dull violet, spherical, minutely spinulose 7–9 (–10) μ in diameter (Text-Figs. 43–48).

This is a strikingly handsome species which could easily be recognized by the stout white stalks bearing the cylindrical steel-blue sporangia that are iridescent before the fugacious peridium drops off.

On leaves and culms of *Eleusine ægyptiaca* Desf., Nazira, Coll.: G. C. S. B., 12–6–1957; (M.H.T.E.S. No. 97); on decaying twigs of undetermined plant, Nazira, Coll.: G. C. S. B., 15–8–1957 (M.H.T.E.S. No. 98); on leaves and petioles of *Mangifera indica* L., Nazira, Coll.: G. C. S. B., 15–8–1957 (M.H.T.E.S. No. 99); on an undetermined substratum, Jorhat, Coll.: H. K. P., 10–10–1957 (M.H.T.E.S. No. 100); on decaying leaves of *Mangifera indica* L., Cinnamara, T. E., Coll:. V. A., 14–11–1958 (M.H.T.E.S. No. 101).

16. ***Stemonitis fusca*** **Roth** in *Mag. Bot. Römer and Usteri*, **1**, p. 26, 1787; Lister, A., *A Monograph of the Mycetozoa*, pp. 132–34, 1925; Martin, G. W., *North American Flora, Fungi-Myxomycetes*, p. 74, 1949; Agnihothrudu, V., *J. Indian bot. Soc.*, **35**, pp. 217–18, 1956, as *S. fusca* (Roth.) Rost.

The specimens collected locally are 10–14 mm. in total height, being somewhat smaller than those recorded from Madras (Agnihothrudu, 1956 *b*). They agree with the description given by Thind *et al.* (1957). The spore size falls between 7–8 (–9) μ and was never found to exceed 9 μ unlike the South Indian form where spores measuring 11·8 μ were not uncommon. Only one collection of this species was made and it has been observed that there is considerable variation in the colour of the sporangia and spores. The spores ranged in colour from greyish-violet to brownish-violet in transmitted light. Similarly,



TEXT-FIGS. 43–48. *Diachæa leucopodia* (Bulliard) Rostafinski (M.H.T.E.S. No. 98). Fig. 43. Fructifications on decaying twig. Fig. 44. Sporangia enlarged.

Fig. 45. Sporangium with peridium intact. Fig. 46. Sporangium without peridium showing capillitial threads radiating from the columella. Fig. 47. Capillitial reticulum. Fig. 48. Spores.

some of the spores were having heavy ornamentations while others were lightly marked which differences are in all probability associated with the size of the spores. On decaying stems of tea bush infected by *Ustulina zonata* (Lév.) Sacc., Tocklai, Coll.: V. A., 14–3–1957, (M.H.T.E.S. No. 174).

17. ***Stemonitis axifera* (Bulliard) Macbride** in *North American Slime-Molds*, p. 120, 1899; Lister, A., *A Monograph of the Mycetozoa*, pp. 138–39, 1925 as *Stemonitis ferruginea* Ehrenberg; Martin, G. W., *North American Flora, Fungi-Myxomycetes*, p. 76, 1949.

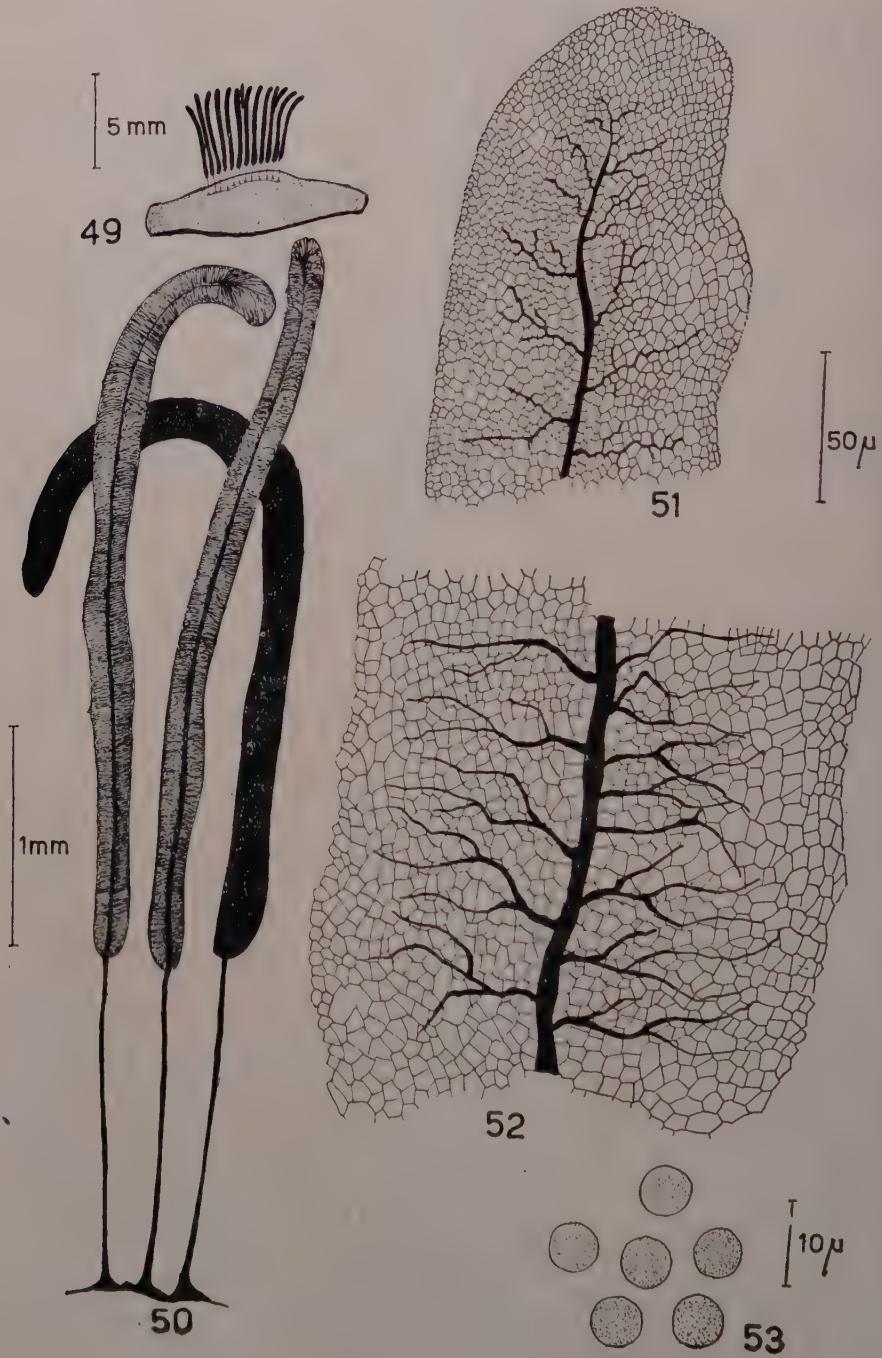
Plasmodium not observed. Total height of the fructifications 10–20 mm.; brilliant rusty-brown in colour, becoming pale brownish on shedding spores; cylindrical, densely fasciculate in small or medium-sized clusters, typically stipitate; stalks setaceous, black, shining, up to one-third to one-fourth of the total height of the sporangium, mostly arising from a well-developed membranous hypothallus which is venulose in some specimens. Columella prominent, dissipating short of the apex of the sporangium. Capillitium arising from the columella, branching freely and evenly forming a close, smooth surface net, connected with the capillitium by means of a few stout branches; the meshes of the surface net vary considerably in diameter. Spores bright reddish-brown in mass, rather pale ferrugineous in transmitted light, almost smooth to minutely punctate, spherical, measuring 5–6 (–7) μ in diameter (Text-Figs. 49–53).

This species appears to be very common locally. The rusty brown colour, the fine meshed surface net of the capillitium and small spores are sufficiently constant to distinguish this species with little or no difficulty.

On undetermined decaying wood, Nazira, Coll.: G. C. S. B., 15–7–1958 (M.H.T.E.S. No. 39); on decaying tea frames, Tocklai, Coll.: V. A.,18–8–1958 (M.H.T.E.S. No. 40).

18. ***Stemonitis virginiensis* Rex** in *Proc. Acad. Philad.*, p. 391, 1891; Lister, A., *A Monograph of the Mycetozoa*, p. 134, 1925; Martin, G. W., *North American Flora, Fungi-Myxomycetes*, pp. 74–75, 1949.

Plasmodium not observed. Sporangia grouped in small clusters, shortly cylindrical, brownish lilac in colour, measuring up to 6 or 8 mm. in total height, distinctly stipitate. Stalk measuring up to 1 mm. long, black, shining, arising from a distinct membranous hypothallus which is confluent in some cases; columella reaching almost the apex of the sporangium, giving rise to a delicate capillitium of flexuose dark-brown threads, the ultimate ramifications uniting to form a closed surface net. Spores pale lilac brown in transmitted light, bright-brown in



TEXT-FIGS. 49–53

TEXT-FIGS. 49–53. *Stemonitis axifera* (Bulliard) Macbride (M.H.T.E.S. No. 49). Fig. 49. A sporangial group on the bark of decaying tea frames. Fig. 50. A group of sporangia. Fig. 51. Capillitium and columella at the apex of the sporangium. Fig 52. Capillitium and columella about the middle of the sporangium. Fig. 53. Spores.

mass, marked with a distinct reticulation of narrow raised bands, 6–10 per hemisphere, measuring 6–8 (–9) μ in diameter (Text-Figs. 54–59).

There seems to be considerable range of colour variation in sporangia in the same collection. Some of the sporangia are cylindrical while others are acuminate. The stalks are although often 1 mm. in height are less than 0·5 mm. in a few specimens collected. The surface net of the capillitium in a few sporangia is found to be incomplete at the apex when the sporangia bear a close resemblance to *Comatricha* sp.

Only two collections are preserved in the herbarium. One on undetermined decaying wood, Jorhat, Coll.: G. C. S. B., 12–6–1957 (M.H.T.E.S. No. 41); the other on decaying frames of tea bushes, Tocklai, Coll.: V. A., 30–8–1957 (M.H.T.E.S. No. 42).

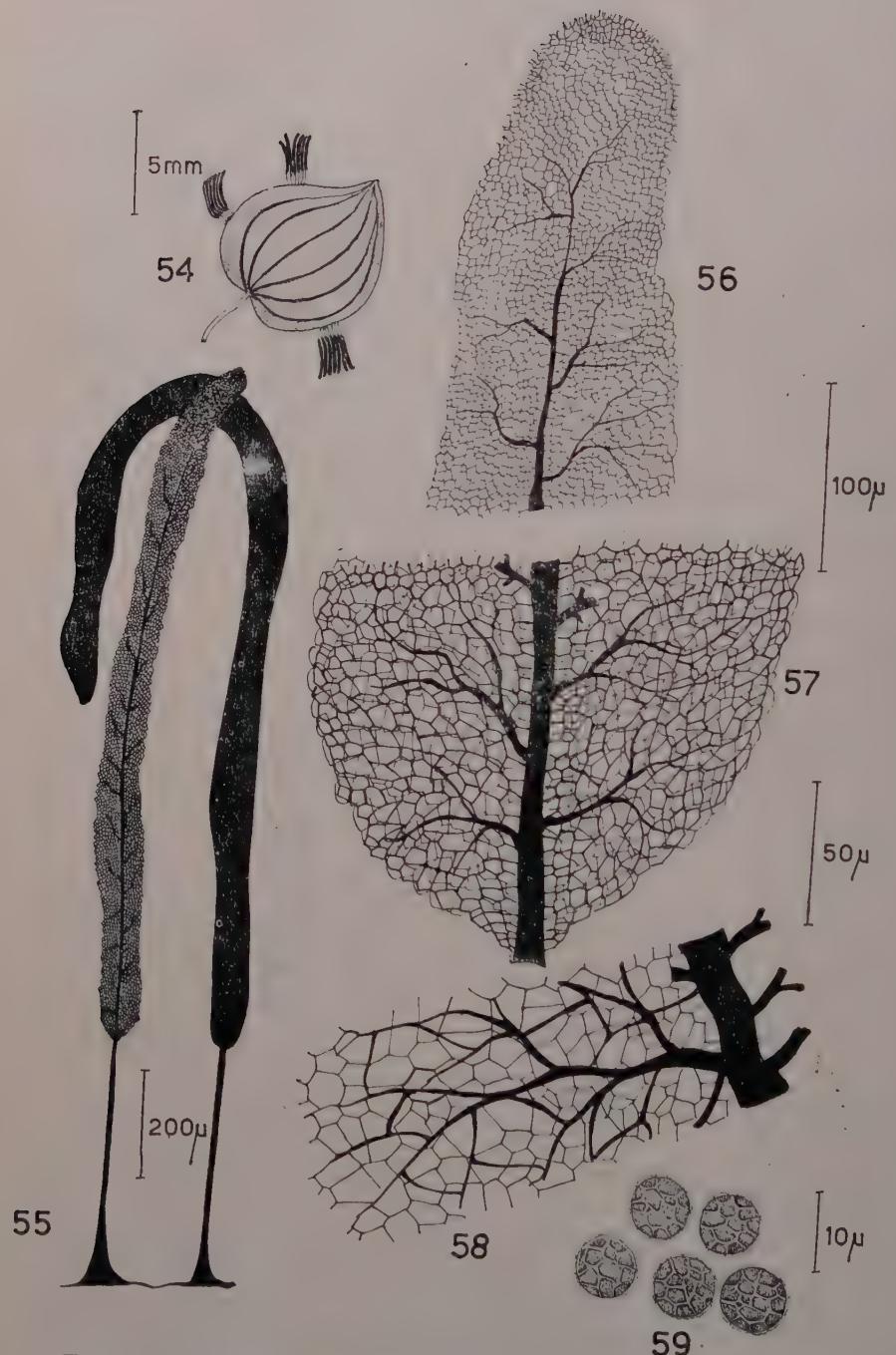
19. ***Stemonitis nigrescens*** **Rex** in *Proc. Acad. Philad.*, p. 392, 1891; Lister, A., *A Monograph of the Mycetozoa*, p. 133, 1925 as *Stemonitis fusca* Roth var. *nigrescens* Torrend; Martin, G. W., *North American Flora, Fungi-Myxomycetes*, p. 74, 1949.

Only two collections of this species were made. No plasmodium was observed. Sporangia are in small groups, gregarious, clustered on a well-developed membranous, confluent hypothallus, erect, cylindric, typically stipitate, measuring 3–6 mm. tall, black or purple brown, becoming fuscous after shedding of the spores; stalk short, black, about 0·5 mm. long; columella almost reaching the apex of the sporangium; capillitial net dense, regular, closed, smooth and complete even at the apex of the sporangium; spores almost black in mass, pale violet-brown in transmitted light, distinctly reticulate, measuring 8–9 (–10) μ in diameter (Text-Figs. 60–64).

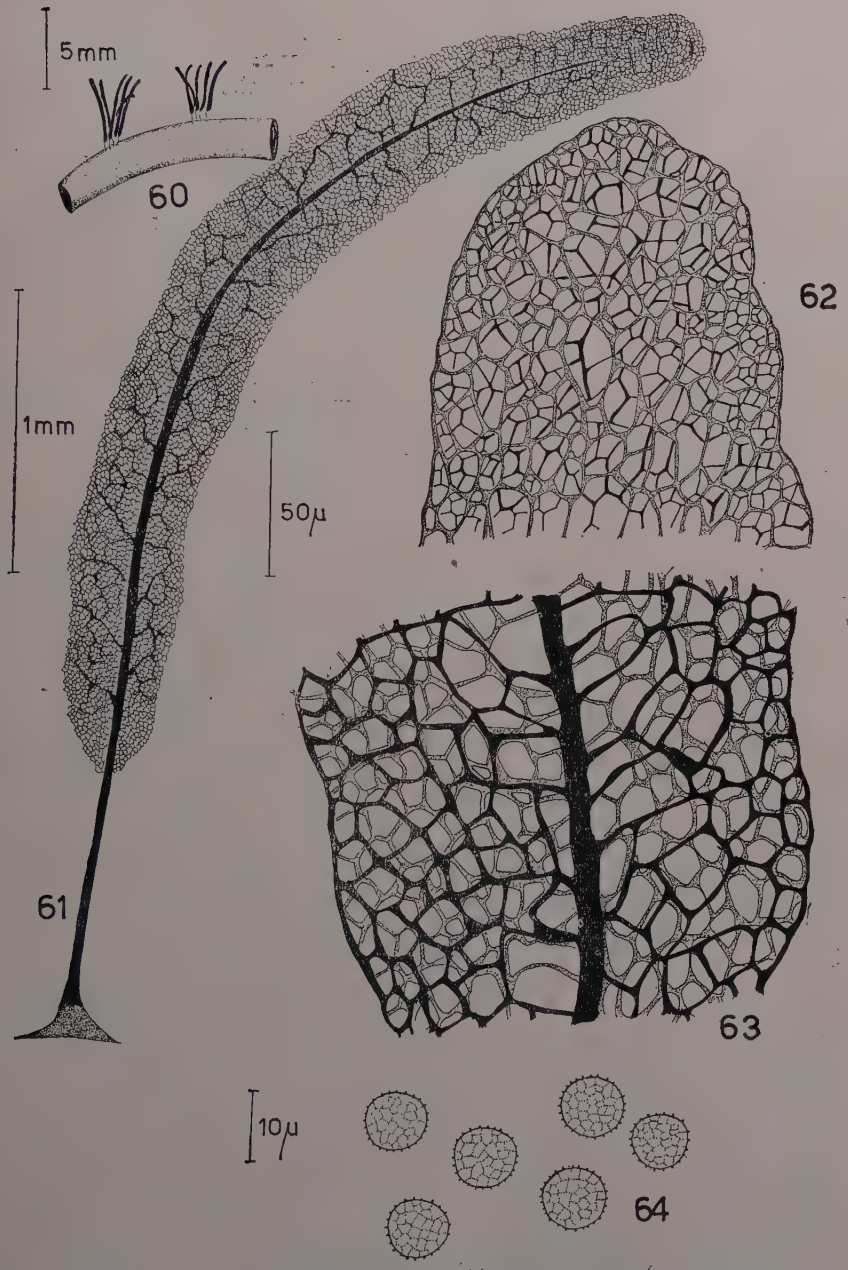
This species is rather uncommon in the neighbourhood of Tocklai and is easily distinguished from *S. fusca* by the smaller size of the sporangial clusters and shorter sporangia which are distinctly blackish or deep purplish-brown in colour.

On decaying twigs of an undetermined host, Jorhat, Coll.: H. K. P., 10–4–1958 (M.H.T.E.S. No. 43); on leaves and stems of an undetermined grass, Tocklai, Coll.: V. A., 22–8–1958 (M.H.T.E.S. No. 44).

20. ***Stemonitis splendens*** **Rostafinski** *Śluzowców* (*Mycetozoa*), *Monografia*, p. 195, 1874; Lister, A., *A Monograph of the Mycetozoa*, pp. 135–36, 1925; Martin, G. W., *North American Flora, Fungi-Myxomycetes*, p. 76, 1949; Thind, K. S., *et al.*, *Res. Bull. E. Panjab Univ.*, **102,** pp. 232–33, 1957.



TEXT-FIGS. 54–59. *Stemonitis virginiensis* Rex (Figs. 55–59 from M.H.T.E.S. No. 42). Fig. 54. Sporangial group on a leaf of *Peperomia pellucida* H. B. K. (not represented in the Herbarium). Fig. 55. A group of two sporangia one of which has shed spores. Fig. 56. Capillitium and columella at the apex of the sporangium. Fig. 57. Capillitium and columella at the base of the sporangium. Fig. 58. A portion of the capillitium enlarged. Fig. 59. Spores.



TEXT-FIGS. 60–64. *Stemonitis nigrescens* Rex (M.H.T.E.S. No. 43). Fig. 60. Sporangial group on a decaying twig. Fig. 61. Sporangium showing the stipe, capillitium and the columella dissipating at the apex. Fig. 62. Capillitial surface net at the apex of the sporangium showing the absence of the columella. Fig. 63. Capillitial reticulum and the columella about the middle of the sporangium. Fig. 64. Spores.

Plasmodium not observed. Total height of the sporangia up to 20 mm.; gregarious, not as closely packed as in *S. fusca*, long, cylindrical, flexous, obtuse at the apex, in many instances the sporangia are pendant. Stalk distinct, deep fuscous, shining, slender, of uniform thickness, measuring up to 5 mm. in length, arising from a well-developed purplish hypothallus which may be confluent; columella reaching almost the apex of the sporangium, rigid. Capillitium consisting of purplish-brown threads, the principal branches of which spring at staggered intervals on the columella, profusely ramified to form a smooth surface net with rounded, angular or variously shaped meshes, measuring up to 20–50 (–70) μ in diameter. Spores purplish in mass, lilac brown by transmitted light, faintly and closely warted, measuring 6–8 (–9) μ in diameter (Text-Figs. 65–69).

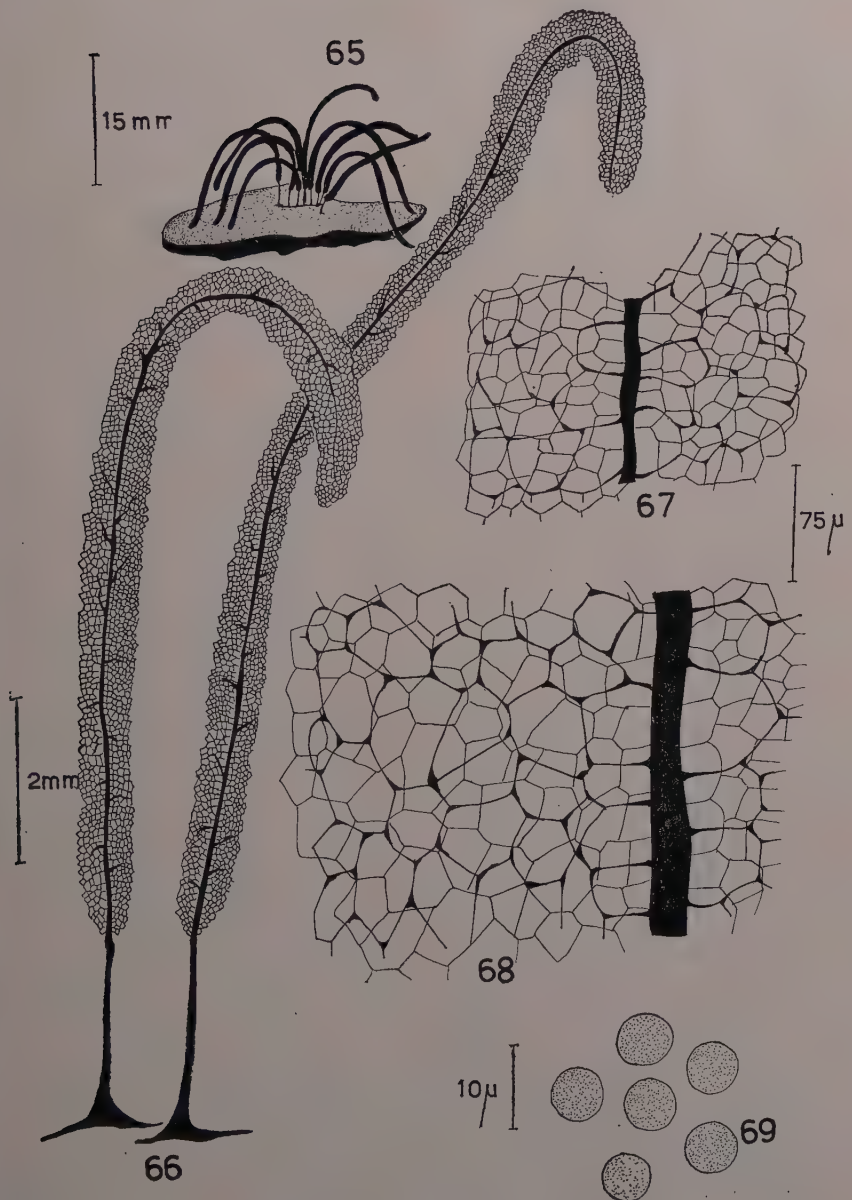
In most of the collected specimens the columella is rigid and straight, in some it is weak and twisted, bent or sinuous so that the sporangia are inclined or undulate. In the same sporangial group, poorly developed capillitial forms are commonly encountered.

On undetermined decaying wood, Nazira, Coll.: G.C.S.B., 12–6–1957 (M.H.T.E.S. No. 45); on undertemined bark, Jorhat, Coll: G. C. S. B. 15–8–1957 (M.H.T.E.S. No. 46); on decaying bark of tea frames, Tocklai, Coll.: V. A., 12–11–1957 (M.H.T.E.S. No. 47); on leaves of *Mangifera indica* L., Jorhat, Coll.: H. K. P., 18–3–1958 (M.H.T.E.S. No. 48); on undetermined substratum, Nazira, Coll.: G. C. S. B., 15–7–1958 (M.H.T.E.S. No. 49).

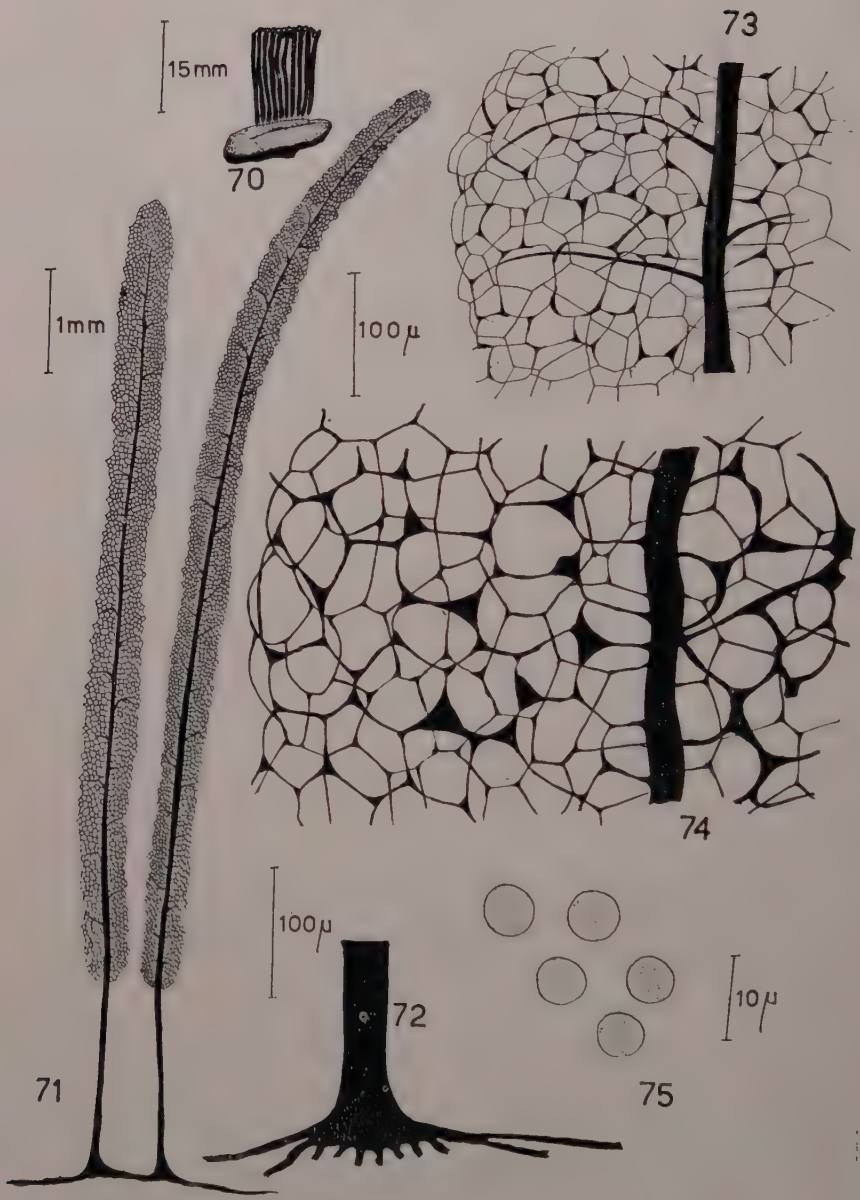
21. ***Stemonitis webberi*** **Rex** in *Proc. Acad. Philad.*, p. 390, 1891; Lister, A., *A Monograph of the Mycetozoa*, p. 135, 1925 as *Stemonitis splendens* Rost. var. *webberi* Lister; Martin, G. W., *North American Flora, Fungi-Myxomycetes*, p. 76, 1949; Thind, K. S. *et al.*, *Res. Bull. E. Panjab Univ.*, **102,** pp. 233–34, 1957.

Plasmodium not observed. Sporangia in small aggregations, crowded, cylindric, purplish-brown, becoming pale purple on dehiscence, measuring up to 15 mm. in height, distinctly stipitate, stalk black, shining, setaceous, almost of uniform diameter, expanding at the base into a large, well-formed hypothallus which is silvery and often provided with rhizoidal processes; capillitium well-formed, often open, arising from a few branches, bearing membranous expansions at the axils of the ramifications, brown in colour with coppery iridescence, the ultimate branchlets uniting to form an irregular surface net; the meshes measure about 40–120 μ in diameter. Spores deep fuscous brown or purple in mass, yellowish brown or brownish lilac in transmitted light, minutely but distinctly warted, measuring 7–8 (–9) μ in diameter (Text-Figs. 70–75).

This is an elegant looking species, undoubtedly very near *Stemonitis splendens* Rost., but differs from it in the open capillitium and large meshed surface net with membranous expansions in the axils of the branches.



TEXT-FIGS. 65–69. *Stemonitis splendens* Rost. (M.H.T.E.S. No. 46). Fig. 65. A lax aggregation of pendent sporangia. Fig. 66. Sporangia showing the hypothallus, stipe, columella and capillitium. Figs. 67 and 68. Columella and capillitium. Fig. 69. Spores.



TEXT-FIGS. 70–75. *Stemonitis webberi* Rostafinski (M.H.T.E.S. No. 50). Fig. 70. Sporangial aggregation on a piece of decaying wood. Fig. 71. Sporangia showing the stipe, columella and the capillitium. Fig. 72. The base of the stipe showing the well-developed hypothallus with rhizoidal processes. Figs. 73 and 74. Columella and capillitium. The capillitium shows, flat, membranous expansions in the axils of the branches. Fig. 75. Spores.

Only one collection of this species is preserved: On undetermined wood, Dr. W. Wight's premises, Tocklai, Coll:. Mrs. W. Wight, 11–6–1958 (M.H.T.E.S. No. 50).

22. ***Stemonitis herbatica*** **Peck** in *Ann. Rep. N.Y. State Museum*, **26,** p. 75, 1874; Lister, A., *A Monograph of the Mycetozoa*, p. 137, 1925; Martin, G. W., *North American Flora, Fungi-Myxomycetes*, p. 78, 1949; Agnihothrudu, V., *J. Indian bot. Soc.*, **35,** pp. 218–19, 1956.

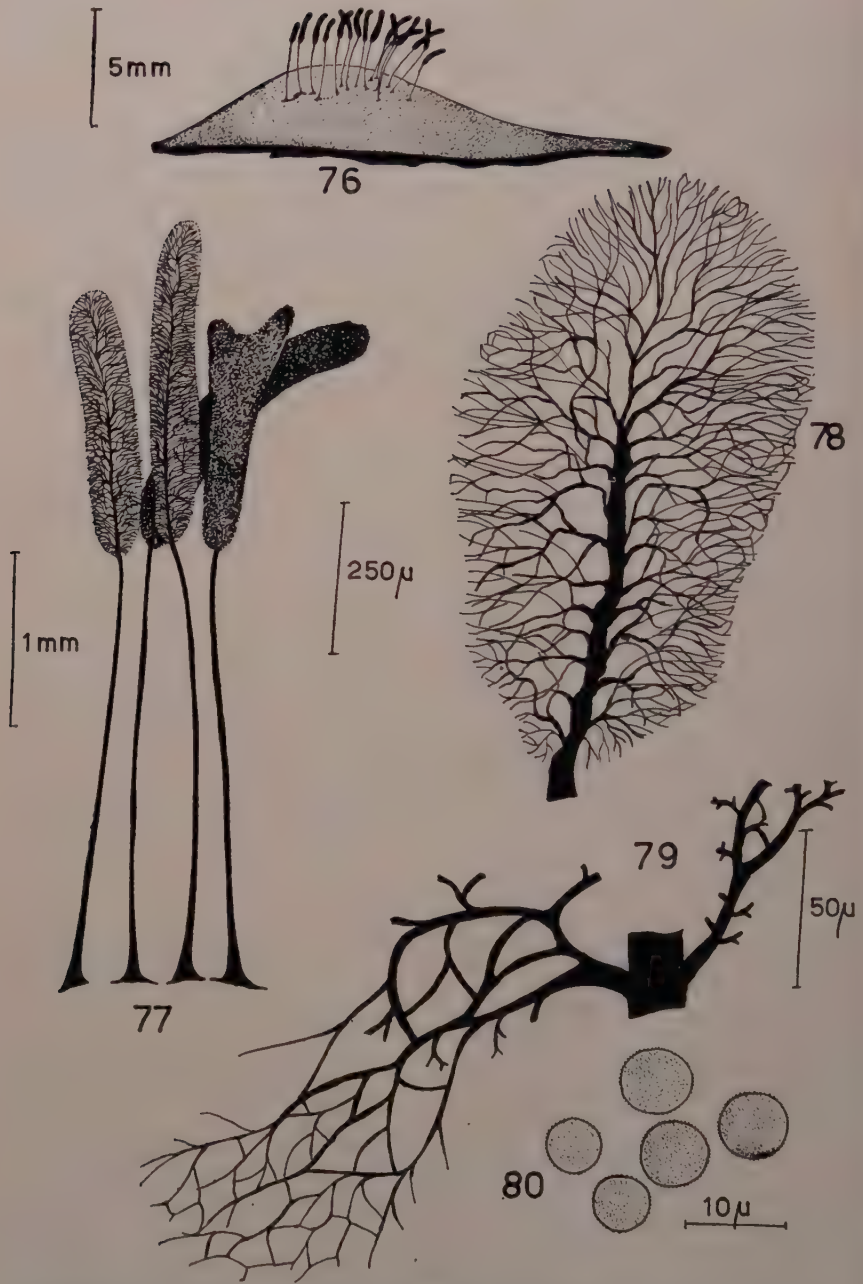
This species is rather rare here and was only once collected on fronds of a fern. The morphology is completely in keeping with the form described from the South (Agnihothrudu, 1956 *b*).

On living fronds of *Pteris* sp., Nazira, Coll.: G. C. S. B., 15–7–1958 (M.H.T.E.S. No. 51).

23. ***Comatricha nigra*** **(Persoon) Schröter** in *Cohn's Kryptogamen-Flora von Schleisien*, **3,** p. 118, 1885; Lister, A., *A Monograph of the Mycetozoa*, pp. 141, 1925, as *Comatricha nigra* Schröter; Martin, G. W., *North American Flora, Fungi-Myxomycetes*, p. 83, 1947.

Only dried remnants of the plasmodium which was watery in colour were observed in a few collections. Total height of the sporangium, up to 5 mm. Sporangia are scattered to subgregarious on the substratum, globose, ellipsoidal or elongate clavate, cylindrical with obtuse or subacuminate ends. In some instances, the sporangia are rather flattened, spathulate and slightly forked at the tip. Perhaps, these are malformed members of the species. Colour dark brown or purplish-black, becoming ferrugineous when the spores are shed. Stipe prominent, 2–4 times longer than the sporangium proper, blackish, shiny, setaceous, arising from a more or less well-formed hypothallus which may be confluent. Columella reaching almost the vertex of the sporangium, there dissipating into the capillitial ramifications; capillitium a dense tangle of purplish-brown threads springing from all parts of the columella, highly ramified, intricately anastomosing and dividing in beautiful arches of nearly equal thickness throughout the length of the columella; giving a spinescent appearance to the surface of the net; spores black in mass, deep violaceous in transmitted light, faintly but distinctly warted, spherical, measuring 7–10 (–11) μ in diameter (Text-Figs. 76–80).

Abnormal forms are quite common which range from short cylindrical or almost subglobose sporangia to long clavate or spathulate forms. The sporangia in the same collection appear to be subject to considerable variation as far as the shape and size is concerned. The stalk varies in length as also the colour and the spore size. The spores in some mature sporangia which are malformed are about 14 μ in diameter and pale fuscous in colour. However, the majority of forms are typical in being long-stalked and clavate, cylindrical, the columella which is



TEXT-FIGS. 76–80. *Comatricha nigra* (Persoon) Schröter (M.H.T.E.S. No. 53). Fig. 76. A lax sporangial aggregation on the bark of decaying tea frames. Fig. 77. A sporangial group showing capillitium and stipe. Figs. 78 and 79. Columella and capillitium. Fig. 80. Spores.

the continuation of the stalk passes through the sporangium to the top with the dense capillitium attached to all parts of the columella.

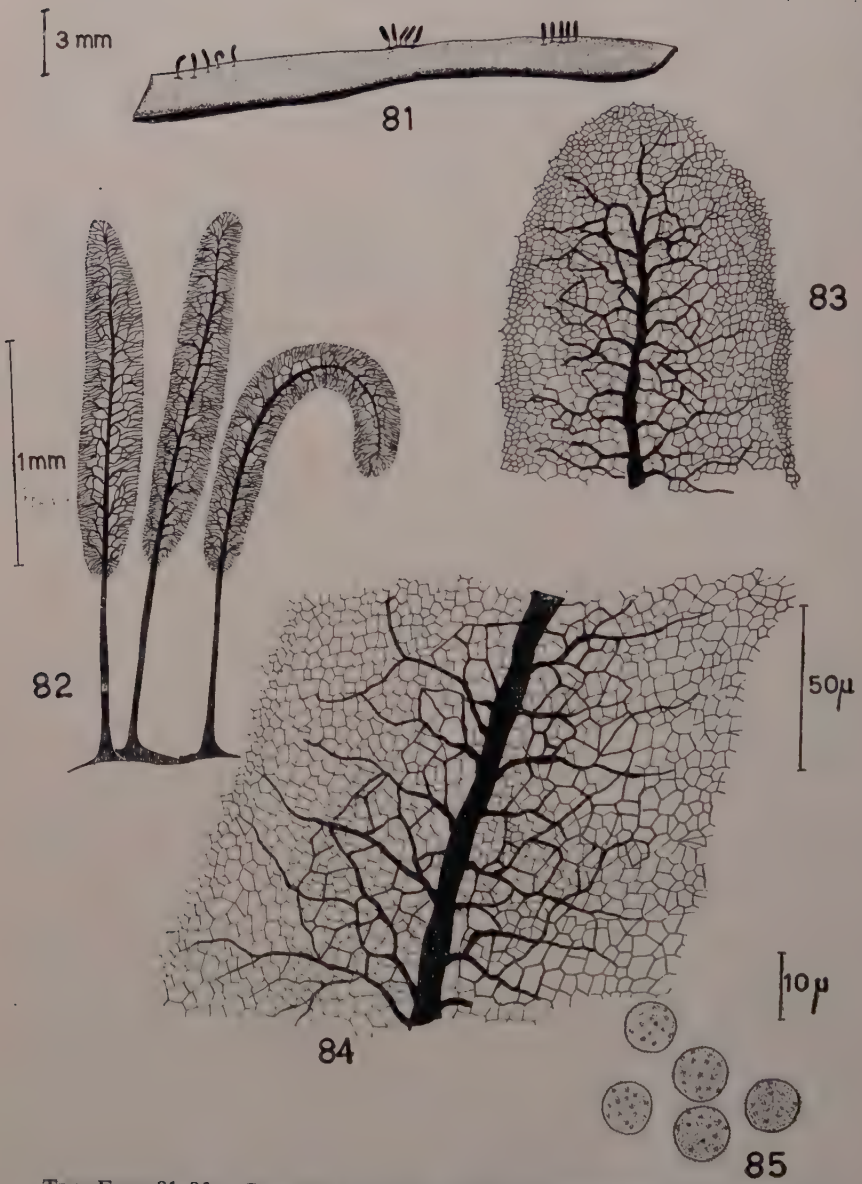
Only two specimens in good condition are preserved: one on the decaying wood of an undetermined host, Jorhat, Coll.: H.K.P., 10–9–1957 (M.H.T.E.S. No. 52); and the other on decaying frames of tea bushes infected by branch canker (*Poria* sp.), Cinnamara, T. E., Coll.: V. A., 14–8–1958 (M.H.T.E.S. No. 53).

24. ***Comatricha typhoides* (Bulliard) Rostafinski** in *Versuch eines System der Mycetozœn*, p. 7, 1873; Lister, A., *A Monograph of the Mycetozoa*, pp. 145, 1925, as *Comatrica typhoides* Rost.; Martin, G. W., *North American Flora, Fungi-Myxomycetes*, p. 84, 1949; Thind, K. S. *et al.*, *Res. Bull. E. Punjab Univ.*, **102,** pp. 236–37, 1957.

No plasmodium was observed. Total height of the sporangia up to 3 mm. Sporangia are formed in lax clusters or almost scattered; stalked, cylindrical, obtuse at the apex, appearing silvery iridescent by the presence of a thin evanescent peridial membrane which ruptures irregularly and peels away from the spore mass exposing the deep purplish-brown spores held together in the capillitial reticulum. Stalk reddish-brown to almost black, clothed in a silvery membrane which is the continuation of the peridial wall. The membrane is fugacious and breaks away in patches from the stalk. Stalk up to 1 mm. long, uniform in width expanding at the base and merging into a well-formed membranous hypothallus which may be confluent. The apical part of the stipe which is somewhat narrow is continued into the sporangium as the columella and almost reaches the apex of the sporangium dissipating on the way into a well-formed capillitium; capillitium a close network of flexuose, pale-brown threads, springing from all parts of the columella, anastomosing and dividing freely to form an imperfect surface net which is complete or in parts open. Spores deep lilac-brown in mass, rather of a paler hue in transmitted light, spherical, distinctly warted, the warts being in groups, measuring 6–7 (–8) μ in diameter (Text-Figs. 81–85).

The species appears to be fairly abundant locally and was observed to show some variety in the density of the capillitium and the extent to which the surface net is formed. The spores are, however, invariably warty in all the collections examined. Forms with stalks almost as long as the sporangia or slightly longer even were indeed encountered although stalks which are about one-third the total length of the sporangia are the commonest.

On decaying bark of *Albizzia procera* Benth., Tocklai, Coll.: V.A., 10–11–1956 (M.H.T.E.S. No. 54); on undetermined wood, Cinnamara, T. E., Coll.: V. A., 11–2–1957 (M.H.T.E.S. No. 55); on an undetermined substratum, Jorhat, Coll.: H. K. P., 17–3–1957 (M.H.T.E.S. No. 56); on decaying leaf sheath of *Areca catechu* L., Nazira, Coll.: G. C. S. B., 15–6–1957 (M.H.T.E.S. No. 57); on undetermined decaying wood, Tocklai, Coll.: H. K. P., 11–11–1957 (M.H.T.E.S. No. 58); on



TEXT-FIGS. 81–85. *Comatrica typhoides* (Bulliard) Rostafinski (M.H.T.E.S. No. 54). Fig. 81. Sporangia on decaying bark of *Albizzia procera* Benth. Fig. 82. A group of three sporangia showing the confluent hypothallus, columella and capillitium. Figs. 83 and 84. Capillitial reticulum and columella. Fig. 85. Spores.

decaying wood of *Mangifera indica* L., Jorhat, Coll.: H.K.P., 14–8–1957 (M.H.T.E.S. No 59).

25. ***Comatricha pulchella* (C. Babington) Rostafinski** in *Dodatek I do monografii Śluzowców*, p. 27, 1876; Lister, A., *A Monograph of the Mycetozoa*, p. 147, 1925, as *Comatricha pulchella* Rost.; Martin, G. W., *North American Flora, Fungi-Myxomycetes*, p. 85, 1949.

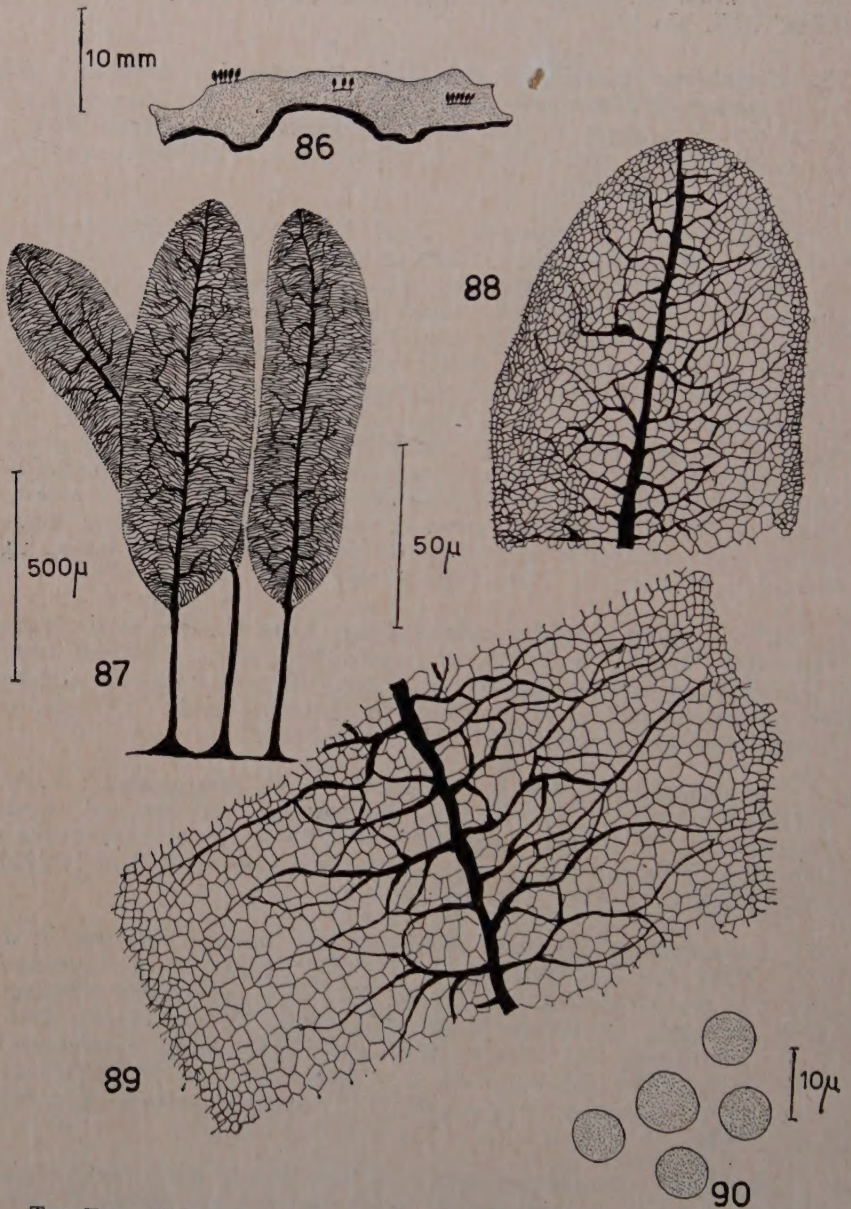
Plasmodium not observed. Total height of the fructifications 0·5 to 1·5 mm. Sporangia scattered or subgregarious, short, cylindrical or almost ovoid in shape, typically stalked, fuligineous, lilac or purple-brown with the sporangial wall which is fugacious. Stalk black, shiny, 0·2 to 0·5 mm. long and always shorter than the body of the sporangium, slightly subulate, expanding below into a well-formed circular and membranous hypothallus which in some cases is confluent giving rise to subgregarious sporangial groups; columella reaching almost the apex of the sporangium giving rise to capillitial reticulum throughout its length; capillitium, a dense network of flexuose, anastomosing pale purplish-brown threads forming almost a closed net with few open ends; spores deep purplish-brown in mass, pale lilac brown in transmitted light, uniformly and distinctly punctate, spherical, measuring 6–7 (–8) μ in diameter (Text-Figs. 86–90).

It is obvious that this species differs from *C. nigra* in the paler capillitium and in the uniformly punctate spores. It differs from *C. typhoides* in possessing generally, a stipe which is much shorter than the sporangium and in the smaller stature of the fruit body. *C. typhoides* besides, has spores which have warts in groups.

On decomposing tea roots buried in soil, Jorhat, Coll.: V. A., 8–11–1957 (M.H.T.E.S. No. 60); on decaying undetermined wood, Nazira, Coll.: G. C. S. B., 15–8–1957 (M.H.T.E.S. No. 61); on tea bush infected by *Ustulina zonata* (Lev.) Sacc., Tocklai, Coll: H.K.P., 6–11–1957 (M.H.T.E.S. No. 62).

26. ***Lamproderma scintillans* (Berkeley and Broome) Morgan** in *J. Cinc. Soc. Nat. Hist.*, **16,** p. 131, 1894; Lister, A., *A Monograph of the Mycetozoa*, pp. 153–54, 1925 as *Lamproderma scintillans* Morgan; Dennison, M. L., *Mycologia*, **37,** pp. 102–03, 1945; Martin, G. W., *North American Flora, Fungi-Myxomycetes*, p. 90, 1949; Agnihothrudu, V., *J. Indian bot. Soc.*, **35,** pp. 213–14, 1956; Thind, K. S., and Sohi, H. S., *Indian Phytopath.*, **9,** p. 163, 1956.

The forms collected here appear to have slightly wider range of size in being 1–2 mm. in total height. The sporangia are mostly 0·5 mm. in diameter and brilliantly iridescent. Unlike the South Indian collection (Agnihothrudu, 1956 *b*), the form occurring here has more persistent peridial walls and the spore size is 7–8 (–9) μ as compared to 6–7 (–8) μ of the form reported from Madras.



TEXT-FIGS. 86–90. *Comatricha pulchella* (C. Babington) Rostafinski (M.H.T.F.S. No. 62). Fig. 86. Sporangia on the bark of a decaying tea bush. Fig. 87. A sporangial group showing the stipe, columella and capillitium. Fig. 88. Capillitium at the apex of the sporangium. Fig. 89. Capillitium about the middle of the sporangium. Fig. 90. Spores.

It is very evident that the remarkable capillitium of this species affords an easy diagnostic feature. It is very rigid and sparingly ramified or unanastomosed until half to two-thirds the distance from the columella. The capillitial threads are pale to almost hyaline towards the columeller and peridial ends.

Only one collection is preserved: on undetermined host, Tocklai, Coll.: V. A., 23–6–1957 (M.H.T.E.S. No. 63).

(*To be continued*)

ANNOUNCEMENT

Commission on Ecology of the International Union for the Conservation of Nature and Natural Resources is arranging a meeting of the Commission at Warsaw from 14th to 29th June, 1960. Discussion will be centered on the following three themes:—

1. The Impact of Man and Modern Technology on Nature and Natural Resources.
2. Management of Wild Grazing Animals in Temperate Zones and Its Relation to Land Use.
3. Ecological Effects of the Biological and Chemical Control of Undesirable Plants and Animals.

Any scientist desiring of presenting paper on any of the above themes may please contact Dr. G. S. Puri, Member of the Commission on Ecology, IUCN., Botanical Survey of India, 7, Koregaon Road, Poona–1, India, for further information.

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